ote technical note techr

Coordination Between Airway Facilities Specialists and Air Traffic Personnel

Sehchang Hah, Ph.D.

April 2002

DOT/FAA/CT-TN02/07

U.S. Department of Transportation
Federal Aviation Administration

William J. Hughes Technical Center
Atlantic City International Airport, NJ 08405

NOTICE

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof. The United States Government does not endorse products or manufacturers. Trade or manufacturer's names appear herein solely because they are considered essential to the objective of this report. This document does not constitute FAA certification policy.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-TN02/07		

4. Title and Subtitle	5. Report Date
Coordination Between Airway Facilities Specialists and Air Traffic Personnel	April 2002
	6. Performing Organization Code ACB-220
7. Author(s) Sehchang Hah, Ph.D.	8. Performing Organization Report No. DOT/FAA/CT-TN02/07
9. Performing Organization Name and Address Federal Aviation Administration NAS Human Factors Group William J. Hughes Technical Center Atlantic City International Airport, NJ 08405	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address Federal Aviation Administration Office of the Chief Scientific and Technical Advisor for Human Factors 800 Independence Ave., S.W. Washington, DC 20591	13. Type of Report and Period Covered Technical Note
	14. Sponsoring Agency Code AAR-100

15. Supplementary Notes

16. Abstract

Airway Facilities (AF) is responsible for providing services and conducting operations that deliver the highest possible levels of National Airspace System (NAS) safety and efficiency. To accomplish this, AF specialists perform maintenance tasks for the NAS. This requires coordination between AF and various organizations including AT. Maintenance Control Center (MCC) specialists have been the focal point of coordination in AF, and AT supervisors are responsible for coordination in AT. AF specialists have been coordinating with AT successfully in the past. However, there has been no empirical research on this important coordination. This report presents the results of the empirical study on coordination. The Human Factors Group (ACB-220) surveyed MCC specialists and AT supervisors about their experience and opinions on coordination. Based on 95 AF and 179 AT respondents, we present recommendations for improving current coordination. The most critical recommendations are to facilitate mutual understanding between AF and AT and to redesign information-related aspects of coordination between them.

17. Key Words	18. Distribution Statement
Air Traffic, Airway Facilities, Collaboration, Communication, Coordination, Information, Maintenance Control Center Specialist, Mental Model, Mutual Understanding	This report is approved for public release and is on file at the William J. Hughes Technical Center, Aviation Security Research and Development Library, Atlantic City International Airport, New Jersey 08405. This document is available to the public through the National Technical Information Service, Springfield, Virginia, 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	110	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Acknowledgments

First, we wish to express our gratitude to all survey participants who volunteered for this project. Without their help, this project was not possible. We appreciate their spending precious time to fill out the questionnaires and return them in a timely manner. We also wish to express thanks to all the AF and AT points-of-contact (POCs) who endured our constant requests and questions. Without their help, support, and encouragement, our project would not have been successful.

Some POCs spent extra time to answer our specific questions about AF and AT operations and coordination. Especially, we want to thank John B. Gardner at Memphis MCC. We visited Memphis MCC in October 2000, and Mr. Gardner helped us understand the complex nature of AF activities and its coordination with AT. Since then, he helped on many occasions by answering various questions on AF and its coordination with AT. We wish to thank other POCs who also answered our various questions for this project. They were Gail Ferguson at Alaska ARTCC, Mike Garay at New York Terminal Radar Approach Control (TRACON), Greg Ingraham at Minneapolis GMCC, Ted Kiladitis at New York AMCC, and Tammie Lewis at Honolulu MCC.

This project is a product of collaboration among many individuals. Especially, subject matter expert Kermit Grayson worked with us as a consultant for the project. Elmer "Al" Nagy (subject matter expert on AT) and John Goldman (subject matter expert on AT, Northrop Grumman Information Technology) also helped us construct the questionnaires. We appreciate Jennifer Hall for her administrative support. We thank David Hess of Art-Z Graphics who helped us to produce the questionnaire forms with a professional look.

We thank Vicki Ahlstrom, Dr. Pam Della Rocco, Dr. Mike McAnulty, Dr. Earl Stein, Dr. Todd Truitt, and Dr. Tanya Yuditsky of ACB-220, and Anton Koros of Northrop Grumman Information Technology for their helpful information and comments for the project. We also thank Jean Dunn of Northrop Grumman Information Technology for her editing of this report and Ron Ford of Northrop Grumman Information Technology for his entering a part of the data into the database. We thank Tommie Jenkins at Elgin GMCC and Arnie Oberson (a retired AF Specialist from Atlantic City AF field office), who also helped us by answering some of our questions on AF.

We wish to express our appreciation to Evelyn Brackman of AAF in D.C. who always answered our questions about the hard-to-find facts on AF promptly. We appreciate Ferrod W. Thomas, Jr. (AFZ-300), Michael D. Fanfalone (National President of the PASS), and Dale Kettring (the PASS representative to AF) for their coordination on this project. This project was funded by AAR-100 and sponsored by AOP-30. We appreciate Dr. Paul Krois of AAR-100 and Bev Clark of AOP-30 who were instrumental for the support.

The following POCs of AF and AT helped us disseminate forms to the participants at their facilities and coordinated with us. Thank you all!

AF

Steve Gallegos at Albuquerque AMCC, Mike Wayne at Boston AMCC
Charles Hollie at Houston AMCC, John B. Gardner at Memphis AMCC
Kevin Sherwood at Atlanta AMCC, Steve Valuch at Chicago AMCC
Bill Kahill at Indianapolis AMCC, Darrell Ashby at Minniapolis AMCC
Lee Traweek at Houston GMCC, John Svoboda at Pacific Desert GMCC
Randy Brown at Seattle GMCC, Greg Ingraham at Minneapolis GMCC
Mark Ciccone at Eastern Region GMCC, Ted Kiladitis at New York AMCC
Hobart Martin at Palmdale AMCC, Lenny Steele at Boston GMCC
Ralph Forrest at Elgin GMCC, Walt Doltman at Oakland AMCC
Link Scoffield at Salt Lake City AMCC, Robert H. Johnson at Atlanta GMCC
Tammie Lewis at Honolulu-HCF

AT

Gail Ferguson at Alaska ARTCC, Roger Mandeville at Albuquerque ARTCC
Alton Self at Atlanta ARTCC, Dan Bueno at Boston ARTCC
Pati Graham at Chicago ARTCC, Rick Kervin at Dallas/Ft. Worth ARTCC
Keith Solt at Denver ARTCC, Francis Thomas at Houston ARTCC
Douglas Molin at Indianpolis ARTCC, Gene Wygal at Jacksonville ARTCC
Tom Wray at Kansas City ARTCC, Ed Frawley at Leesburg ARTCC
Charles Taylor at Memphis ARTCC, Pete Gullo at Miami ARTCC
Jack Huber at Minneapolis ARTCC, Charles Bailey at New York ARTCC
Ralph E. Marsh at Oakland ARTCC, Richard Kettell at Ohio/Oberlin ARTCC
Robert Neher at Palmdale ARTCC, Joe Poirier at Salt Lake City ARTCC
Cliff Nelson at Seattle ARTCC, Joel Forrest at Atlanta ATCT
Randy Breedlove at Charlotte ATCT, Sam Kohn at JFK International Airport ATCT
Marvin Shappi at Los Angeles ATCT, Craig Chandler at Orlando ATCT
Tim Eastburn at Philadelphia ATCT, Larry Samson at Phoenix ATCT
Ron Beckerdite at Seattle ATCT, Anne Hulsey at Chicago TRACON
Jeff Techenor at Denver TRACON, Michael Garay at New York TRACON
Martin Hardy at Phoenix TRACON, and Ronald Popper at Southern California TRACON

Table of Contents

Table of Contents (Cont.)

Appendices

List of Illustrations

Figure Page

Table Page

Executive Summary

Airway Facilities (AF) is responsible for providing services and conducting operations that deliver the highest possible levels of National Airspace System (NAS) safety and efficiency. To accomplish this, AF specialists perform maintenance tasks for the NAS. This requires coordination between AF and various organizations including AT. Maintenance Control Center (MCC) specialists have been the focal point of coordination in AF, and AT supervisors are responsible for coordination in AT.

AF specialists have been coordinating with AT successfully in the past. However, there has been no empirical research on this. The NAS Human Factors Group (ACB-220) performed a survey of MCC specialists and AT supervisors about their experience and opinions on coordination. We present the results of the empirical study on coordination in this report.

We collected demographic data, general characteristics of coordination, and other specific coordination characteristics. We also asked their opinions on their current coordination obstacles and suggestions for better coordination. We sent out 652 survey forms (282 AF forms to 12 Air Route Traffic Control Center MCCs [AMCCs] and 12 General MCCs and 370 AT forms to 21 Air Route Traffic Control Centers [ARTCCs], 5 Terminal Radar Approach Controls, and 8 Air Traffic Control Towers [ATCTs]) and received 283 forms. This represents a 43% return rate. Among them, we analyzed 95 AF and 179 AT forms. Based on the respondents' data, we present the following recommendations:

- Facilitate mutual understanding between AF and AT. Our data and the previous research on coordination of other organizations showed that it is important to understand the others' needs and responsibilities for efficient coordination. As some respondents suggested, it would facilitate their mutual understanding and make their coordination more effective if they interact more often by receiving training together and holding joint meetings.
- Devise measures to improve the information-related obstacles in the current coordination between AF and AT. They were the major obstacles according to AF and AT respondents. Specifically, they cited information quality, finding coordinators, and receiving the relevant information in a timely manner. The Federal Aviation Administration (FAA) needs to examine these separately and resolve the current information-related problems.
- Make the important, helpful information available to the AF and AT coordinating personnel. Some AF and AT respondents expressed that certain information was not available but could be useful for coordination if available, such as the information on the real-time traffic flow for the AF personnel. Some AT respondents mentioned that the information about equipment at nearby facilities and AF technicians' travel-time to the maintenance site could be beneficial. When AF and AT personnel coordinate, they usually use face-to-face or telephone communication. Thus, if some information is relayed by computers automatically, the coordinators can save time. Some AF respondents also thought that there were too many organizations with whom to coordinate. If AF personnel can extract the necessary information using computers easily, they may not need to coordinate with all the organizations they currently deal with. The Event Manager software of AF supplies most of the necessary information. The FAA needs to make the information available to both AF and AT.

- Increase the number of AF specialists who coordinate with AT. Twenty-one AT respondents mentioned that low AF and AT staffing was a major obstacle. Fifteen AT respondents suggested hiring more AF specialists. Improving coordination procedures may also improve this situation.
- Make the coordination procedure known to the AF and AT personnel who are not the main designated coordinators but may be called upon to coordinate.
- Create a separate, local coordination procedure. The current data and previous studies on coordination suggest that local control and face-to-face communication are effective for coordination. Even if the coordination will be handled by three centralized Operations Control Centers as planned by the FAA, it may be beneficial to leave certain types of coordination at the local level and let the local AF sites handle the coordination between them and AT. This requires the FAA to create a local procedure for certain coordination tasks.
- Make coordinators' roles and responsibilities clear to AF and AT coordinators. The current roles and responsibilities are not clear to some coordinators. These should be clearly known to them. The FAA needs to give them training on this.
- Standardize the terminology. Some AF and AT respondents mentioned that the technical terminology created problems in communicating. The FAA needs to standardize the technical terms and make them available to AF and AT personnel.
- Study if AF and AT can respond faster to the other's request. AF respondents thought the current AT's response time was not ideal. The FAA could use the response times reported here by AF and AT as a guide and see if AF and AT could improve response times. Less optimal response times for both parties may be due to their misunderstanding the necessary coordination procedures.
- Initiate a new study to examine issues raised by this study. Since this is a baseline study, we could not address all of the issues. For instance, we do not know if empowering is useful for AF and AT coordination. Currently, AF does not often empower the other organization. In the Air Traffic Management environment, empowering has been effective for coordination between AT providers and users. We need to study this further to determine if empowering will benefit AF and AT coordination.

1. Introduction

Airway Facilities (AF) is responsible for providing services and conducting operations that deliver the highest possible levels of National Airspace System (NAS) safety and efficiency (Federal Aviation Administration [FAA], 1999a). To accomplish this, AF specialists perform maintenance tasks for the NAS. The tasks may be periodic maintenance to "minimize unscheduled interruptions as well as extend life of the equipment and infrastructure" or corrective maintenance to restore the NAS service "after an outage or unscheduled interruption" (FAA, 1999b, p. 2). This corrective maintenance also includes "fault detection, troubleshooting, fault isolation, and replacement of any failed components" (FAA, 1999b, p. 2). To perform these maintenance tasks, AF specialists usually need to coordinate with personnel at various organizations, including Air Traffic (AT).

When two or more organizations work together to accomplish a task, they need to coordinate. However, coordination is not limited to organizations. As Malone and Crowston (2000) pointed out, coordination occurs in "many kinds of systems: human, computational, biological, and others" (p. 6). They defined coordination as "managing dependencies between activities" (p. 6). This coordination becomes difficult as the tasks get complex and coordinating organizations are diverse. One good example is the coordination involved in building the Boeing 767-F (Klein, 2000). To build it, many people in different disciplines needed to work together to put millions of parts in place. Because of design conflicts, they reworked from 25 to 30% of the airplane design. Also, about half of the labor cost of the Boeing 777 program was due to "changes, errors, and rework, often due to design conflicts " (p. 2). Such waste could have been avoided with more efficient coordination management. Even though the coordination between AF and AT involves only two organizations, the implication of failed coordination to NAS safety is enormous. Therefore, the efficient and seamless coordination between these two organizations is very critical for the NAS.

In 1997, the FAA presented new operational concepts of air traffic service to be realized in 2005 (FAA, 1997b). In the proposal, they emphasized "a human-centered approach" (p. 2) to efficiently deliver air traffic services to users. The FAA anticipated that by 2005, new technologies like the Global Positioning System would be adopted. The first initial tests of Free Flight would be completed, and the Host en route automation system would be installed. The FAA predicted that the NAS would have new, improved capabilities.

One of the major characteristics in this new NAS is increased coordination between the NAS providers and users (FAA, 1997b). Even if the NAS providers and users have coordinated well in the past, they realized that new ways of coordination would facilitate coordination between them and make the NAS safer and more efficient.

To that end, one of the major focuses in modernizing the NAS is to facilitate "information services for collaboration and information sharing" (FAA, 1999c, p. 2). This philosophy of coordination was extended to the NAS infrastructure maintenance. Maintenance service will be more centralized, and AF specialists will rely more on monitoring and control. This will "facilitate collaboration between service providers and users, allowing users to participate in prioritizing scheduled and unscheduled repairs to essential NAS equipment" (FAA, 1999c, p. 4).

Research has identified a number of factors involved in successful coordination. Sharing information was the most critical factor (MacDonald, 1998; Smith et al., 1998). Another important factor was the shared mental model. All parties needed to have shared knowledge

about the task (Converse, Cannon-Bowers, & Salas, 1991; Langan-Fox, Code, & Langfield-Smith, 2000; Smith et al., 1998). Communication and communication methods were other important factors (Smith et al., 1998; Warkentin, Sayeed, & Hightower, 1997).

Research has shown that face-to-face communication is the best method for coordination (Warkentin et al., 1997). Nevertheless, AF and AT personnel cannot always communicate face-to-face because they are geographically separated. It is important to relay necessary information on time and receive feedback in a timely manner (Smith et al., 1998). Participants also need to understand their roles and responsibilities clearly (Smith et al., 1998) as shown in Air Traffic Management (ATM) Collaborative Decision Making (CDM) in the U.S. and Europe (Eurocontrol, 1998; Metron, Inc., 2000a).

Based on the literature on AF and AT and discussions with subject matter experts, AF and AT personnel may not share information extensively. AF specialists' notice of maintenance schedules may not be as timely as AT personnel wish. AF specialists may not receive AT's response to their requests in a timely manner. Also, both AF specialists and AT personnel may not have clear ideas of the others' tasks and responsibilities.

We are also interested in what information they request, how they communicate, what information they record, and what memory aids they use. We are interested in their opinions about the obstacles to coordination and their suggestions for better coordination. Their opinions will be useful to make the NAS more efficient and safer in the future. The results in this research show a clear picture on the current coordination between AF and AT for the first time. This study is part of a series to study communication and coordination in AF (Ahlstrom, Koros, & Heiney, 2000).

1.1 Background

1.1.1 Coordination in Air Traffic Management

1.1.1.1 Coordination in the U.S.

Since 1991, CDM has been an integral concept for the FAA to enhance the use of the NAS within the constraints imposed by the Air Traffic Control System Command Center (Metron, Inc., 2000b). The FAA CDM program encourages service providers (Air Traffic Control Specialists (ATCSs), traffic flow managers, and AF operators) and service operators (airline pilots, general aviation pilots, and military pilots) to share information on flight management. The most important benefit of using CDM has been sharing information among participants to reach an optimal decision for providers and users (MacDonald, 1998).

CDM became official in 1995 and the NAS users, the FAA officials, and government contractors formed a group to promote it. As their first effort to apply CDM to ATM, they defined NAS providers' and users' roles and responsibilities (Metron, Inc., 2000a). Air Traffic Control-Traffic Flow Management (ATC-TFM) monitors the NAS, informs the users about the operational constraints, and develops a solution if constraints create problems. Airline Operational Control keeps ATC-TFM informed of the current operational demands and intent and provides business needs and plans. Through these roles and responsibilities, they define the specific coordination tasks to improve air traffic flow and safety.

The CDM program in the U.S. has been successful, resulting in a number of enhancements to traffic flow and the system as a whole. Recently, Beatty, Corwin, and Wambsganss (1999) presented concrete data showing the time saved in minutes when CDM was applied to

reallocating landing slots dynamically. According to Beatty et al., "more than 2 million minutes of delays were saved by reallocating landing slots" (p. 443) since August 1998.

1.1.1.2 Coordination in Europe

Eurocontrol adopted the U.S. CDM model and considers it as a concept to improve "the way ATM, Airlines, and Airports work together at an operational level. It means putting power in the hands of the people best placed to take decisions" (Eurocontrol Experimental Center, 2000, p. 1). Their goal is to make the "best use of available resources" and "give Aircraft Operators more flexibility" (Eurocontrol Experimental Center, p.1) in their scheduling. They proposed that, for ATC in the year 2000 and beyond, collaborative planning and decision making would be the core element. Eurocontrol acknowledged the difference between European and U.S. ATM environments in terms of infrastructure, operating procedures, legality, and commerce (Eurocontrol, 1998).

1.1.1.3 Coordination in Airway Facilities

Air traffic coordination in the U.S. and Eurocontrol environments in which CDM has been applied is different from the coordination in the AF and AT environments. Some of the key concepts stressing flexibility and information exchange can be applied, however. Coordination in AF is not a new concept because AF specialists have been coordinating with AT and other organizations successfully for maintenance tasks. AF supports ATCSs, traffic management personnel, specialists at Flight Service Stations (FSSs), and pilots, and therefore, AF specialists have a direct relationship with those NAS users. Thus, the coordinated planning and decision making between AF specialists and the users of the systems and facilities are critical for the NAS efficiency and safety.

1.1.2 AF Structure

According to the Airway Facilities Strategic Plan (FAA, 1997a), "AF is responsible for NAS Service Management, guaranteeing the safety, efficiency, and quality of delivering NAS services" (p. 7). Therefore, the maximum availability of equipment for the NAS is the prime responsibility of the AF specialists. AF specialists monitor, control, maintain, and certify the NAS facilities. In addition, they are responsible for certification of equipment, systems, and services (National Research Council, 1997). There are over 11,000 AF employees (FAA, 2000a) and 7,200 AF specialists, according to the AF office in D.C. (e-mail message from Ms. Evelyn Brackman of the AF on May 31, 2000). The central control center of AF is the National Maintenance Control Center (NMCC). (Note: This became the National Operations Control Center [FAA, 2000b]). Under this NMCC, there are 42 regional Maintenance Control Centers (MCCs) (FAA, 2000c), and 488 MCC AF specialists work in these centers (according to Ms. Brackman of the AF, e-mail message on October 26, 2000). These specialists monitor, control, and certify facilities and dispatch personnel to restore facilities and service. They are also the focal point of coordination on all AF maintenance activities.

There are two kinds of MCCs: the Air Route Traffic Control Center (ARTCC) MCC (AMCC) and the General MCC (GMCC). (Note: Since we collected the data for this study, the AF structure has been changed. GMCCs were dissolved into one of Atlantic, Mid-States, or Pacific Operations Control Centers. ARTCCs became Service Operations Centers.) AMCCs are collocated with ARTCCs. The AMCC's task is to maintain equipment and systems in the ARTCC complex. They are also responsible for coordinating the maintenance activities of

facilities that serve the ARTCC directly and exclusively. These facilities include Air Route Surveillance Radar (ARSR), Air Traffic Control Beacon Interrogator site, and Remote Communications Air/Ground facilities. GMCCs are responsible for all coordination activities for facilities that support the terminal environment and en route navigational aids (FAA, 1999a; FAA, 1999c). (Note: The MCC specialists who work in GMCCs are called NAS Operations Managers [NOMs]. In the following, MCC specialists will mean both MCC specialists and NOMs.)

1.1.2.1 AF Coordination Tasks with AT

According to the FAA Handbook (FAA, 1999b), in the AF, MCC AF specialists require coordination with AT personnel under the following conditions:

1. whenever an interruption or an impending interruption of service is perceived by a user.

   Routinely the MCC AF personnel will not start their activities until the appropriate ATC facility has been notified and the release approved;
2. immediately upon equipment failure or upon notification that a facility is out of service because of equipment failure;
3. when transferring the facility to standby power;
4. whenever service can be restored after an interruption of a system, subsystem, or equipment;
5. when construction or modernization may cause interruptions;
6. when the certification has been removed, or the maximum certification interval has been exceeded; and
7. at anytime when there is a possibility of delayed ATC operations.

From the AT side, AT supervisors are responsible for coordination with AF.

1.1.2.2 AF Maintenance Procedures

Major coordination procedures between AF and AT are 1) Unscheduled Events, 2) Scheduled Events, 3) Flight Inspection (FI) Events, and 4) Service Interruptions (FAA, 1999b). In the following subsections, AF maintenance procedures that need to be coordinated with AT are summarized from the General Maintenance Handbook for Airway Facilities (FAA, 1999b).

1.1.2.2.1 Unscheduled Facility Interruptions

Urgent maintenance activities are handled immediately. To prevent unscheduled facility interruptions, the Systems Maintenance Office (SMO) manager develops a risk management plan. The SMO manager establishes priorities for not-so-urgent restoration of out-of-service facilities based on this plan. However, AT personnel determine the priority of two or more facilities, systems, or equipment when they are not operative at the same time.

In addition, if switching or changing equipment creates any momentary interruptions or abnormal states, MCC AF specialists need to give a notice to and receive an approval from the appropriate AT personnel.

If communications or surveillance services are found to be below standards, AF specialists will decertify it and advise AT of the system or equipment condition. Continuous use of the equipment is optional for AT personnel.

1.1.2.2.2 Scheduled Facility Interruptions

For scheduled facility interruptions, MCC AF specialists need an approval from AT. Local risk management established by the collaborative effort of AF and AT is used to determine the impact to the NAS. After scheduling, MCC AF specialists notify the appropriate AT personnel of a scheduled outage no later than the day preceding it, whenever possible. A scheduled outage of most systems and equipment must be advertised by Notice-to-Airmen (NOTAM) at least 5 hours in advance.

MCC AF specialists use the following interruption coordination procedure:

- They request, through their coordinating entity, the authority to remove equipment from service and inform them of the desired time of shutdown, probable duration, and reason.
- They coordinate the request with AT personnel and all other appropriate entities, obtain approval or justification for refusal, and advise the requesting specialists or organization of the results.
- They coordinate with the military, as needed.

After the completion of a scheduled interruption, MCC AF specialists notify the NMCC (Note: This became National Operations Control Center [NOCC].) and appropriate AF Control Centers, and report in accordance with the National Airspace Performance Reporting System. If MCC AF specialists request a scheduled interruption and it is denied by AT, they report this through proper channels with all the pertinent information.

1.1.2.2.3 Flight Inspection Procedures

For a FI, MCC AF specialists may perform non-routine maintenance. They may need to coordinate with FI scheduling personnel. They will

a. verify the report with another aircraft if the aircraft reported a navigational aid facility malfunction;
b. check if there is a stand-by equipment. If it is available, AT uses it if a malfunction is reported by a second aircraft;
c. immediately request a NOTAM removing the suspect aid if there is no stand-by equipment;
d. notify AT personnel of the pertinent facts concerning restoration.

1.1.2.2.4 Service Interruptions

Local risk management shall be done to determine the impact of service interruptions on the NAS. Coordination is required for any scheduled service interruption for any length of time. Requests for authority to interrupt service, whether the service is scheduled or unscheduled, shall be directed to the NMCC. MCC AF specialists notify the appropriate AT personnel on the day preceding a scheduled service interruption, whenever possible, to allow AT personnel sufficient time for activities such as planning, rerouting, and publishing. Upon restoration of service, proper notification shall be made to the NMCC.

1.1.3 Critical Aspects of Successful Coordination

After the official installation of CDM in ATC-TFM in 1995 by the CDM group (Metron, Inc., 2000b), Smith et al. (1998) initiated a study on the issues of CDM in TFM. They identified four factors that could lead to successful coordination. They are

a. shared understanding (or mental models),

b. distribution of responsibilities,

c. process control and feedback, and

d. staff selection and communication channels.

They found that the parties involved in coordination also had different responsibilities and goals. This provided a check and balance on their decisions. When a request was disapproved, it was beneficial for airline planning if they were given the reasons. Smith et al. (1998) concluded that coordinators must have good interpersonal and communication skills in addition to good knowledge of the ATC system.

Smith et al. (1998), Converse et al. (1991), and Langan-Fox et al. (2000) pointed out that participants needed to have a shared mental model for effective coordination. This shared mental model is the member's common experience, knowledge, and memory required to perform the task.

To coordinate activities across organizations, participants should have a clear, common goal even if they may have different motives. It is essential for them to be informed of the constantly changing information of the situation, so they will be ready to solve problems with the common and updated information at any time (Smith et al., 1998). In the case of AF specialists, they do not have much time to build common knowledge on a particular task with AT personnel. However, because they have worked with AT personnel in the past, they may have established the necessary common knowledge of the task. They may need to exchange some detailed background information. AF specialists and AT personnel have different levels of knowledge and technical background on equipment and systems. Therefore, they may have problems in communicating the necessary requirements to accomplish a task. They may also use different terminology for the same equipment and systems. This may create a communications problem, making coordination more difficult.

Depending on the nature of a coordination task, a certain communication method may be more efficient than others. Warkentin et al. (1997) showed that if coordination was done electronically or virtually, participants experienced team-building problems and got less satisfaction in the process than when they coordinated face-to-face. However, as pointed out by Smith et al. (1998), the information will be lost in the face-to-face method if it is not stored in another medium. Currently, coordination between AT and others is frequently carried out either face-to-face or through telephone communication (Lacher & Klein, 1993; Smith et al., 1998). This is a good method in the sense that the participants will get immediate feedback and further clarification, if necessary. However, the participants must be there to get the information, and only the person on the telephone receives it. That person may need to disseminate the information to other people.

1.2 Purpose

The objective of this research project is to study the coordination between MCC AF specialists and AT personnel in scheduling maintenance activities as they do it today. The past research on coordination in ATM and other areas showed a few important factors for efficient coordination (Converse et al., 1991; Klein, 2000; Lacher & Klein, 1993; Langan-Fox et al., 2000; MacDonald, 1998; Malone & Crowston, 2000; Smith et al., 1998; Warkentin et al., 1997). However, none of these studies addressed coordination between AF and AT.

2. Method

Because of their unique environments and tasks, coordination between AF and AT may be different from coordination in other areas. To study this empirically, we asked MCC AF specialists and AT personnel directly about their experience and opinions on coordination. Our research purpose is to show a baseline profile of the AF-AT coordination.

The major research questions are listed below.

a. What are the general characteristics of MCC AF specialists' coordination with AT personnel such as: how long they have worked at their current position, what the critical factors for successful coordination are, when they coordinate most during a day, if roles in coordination are well defined (cf. Metron, Inc., 2000b, p. 1), and the successful aspects and obstacles of the current coordination.

b. For each of three events (i.e., unscheduled events, scheduled events, and FI events), we asked AF personnel what particular information they collected from AT, and what they shared with AT concerning maintenance. Based on this, we explored what information was critical for AF and AT to coordinate for specific events.

c. Exchanging and sharing relevant information, taking into account the other participants' needs and priorities, and giving the decision power to the right participant are required to make coordination successful (Eurocontrol, 1998; Lacher & Klein, 1993; MacDonald, 1998; Smith et al., 1998). We investigated if the MCC AF specialists and AT personnel currently perform these.

d. We identified current communication methods for AF and AT coordination. The efficiency of the communication and recording methods may depend on the nature of coordination tasks (Smith et al., 1998; Warkentin et al., 1997).

e. It is important to send information well in advance and also to receive feedback in a timely manner for efficient coordination (Smith et al., 1998). We asked AF specialists and AT personnel about this to see if they receive notice and feedback in a timely manner.

f. To coordinate efficiently, AF and AT personnel need to have shared knowledge and mental models on each other (Converse et al., 1991; Langan-Fox et al., 2000; Smith et al., 1998). To examine this, we asked AF specialists if they knew much about AT personnel's tasks and responsibilities. We also asked AT personnel the same question about AF specialists. To examine this issue further, we asked AF specialists if AT personnel understood AF roles and responsibilities. We asked AT personnel the same question concerning AF's understanding of AT roles and responsibilities.

g. Some AF and AT questions are similar. We examined the difference in AF's and AT's answers to the same questions.

h. The major maintenance tasks of AMCCs and GMCCs are the same, but some of their tasks are different because of different work environments. We compared their responses to questionnaires.

2.1 Participants

According to Dillman (2000), it would be ideal to have 80 as the sample size from a population size of 488. This is based on the assumption of the plus and minus 10% sampling error and 95% confidence level with a 50/50 possibility split. This 50/50 possible split is the expected possibility that 50% of respondents would say "yes" and 50% of them would say "no" to a dichotomous question. This is a conservative estimation. Assuming about 30% as the survey return rate, we needed to send out at least 240 questionnaires to MCC AF specialists to satisfy the above guideline.

2.1.1 AF Specialists

We sent out questionnaires to 24 randomly chosen MCCs (12 AMCCs and 12 GMCCs) out of 42 MCCs. This categorization of AMCC and GMCC is based on the information presented on the FAA web site on April 6, 2000 (FAA, 2000c). We sent out 282 questionnaire forms (Appendix A). At each MCC, we had a supervisor as a point-of-contact (POC) who distributed questionnaires to MCC specialists.

2.1.2 AT Personnel

To understand the perspectives on coordination from the AT side, we sent out similar questionnaires to AT personnel (Appendix B). We excluded FSSs because AF coordination with FSS is somewhat different from that with other AT environments, and we wanted to limit our scope.

In AT, supervisors are responsible for coordination with AF (FAA, 2001a, paragraphs 2-6-1 & 17-3-2). (Note: Ms. Gail Ferguson at Alaska ARTCC pointed out this FAA order for us.) We sent out 370 questionnaires to AT supervisors at 20 ARTCCs, 5 Terminal Radar Approach Controls (TRACONs), and 8 ATCTs. These facilities were selected without consideration to match the AF sites we selected.

2.2 Materials

Based on research and interviews with Subject Matter Experts (SMEs), we decided to use a survey as the research method instead of using interviews, because we could reach more personnel and it was less intrusive than interviews. To construct the survey questionnaires, we used the issues of CDM in ATM and previous research on coordination as variables in addition to those derived from our consultation with SMEs on MCC AF specialists' coordination with AT.

To develop the research questions, we first examined MCC AF specialists' tasks, standard operating procedures, and information exchanges in coordination with AT. We produced charts to show these in detail. In the charts, we listed tasks of maintenance events in chronological order. For each task, we described various aspects of coordination activities such as originators of coordination, information exchanged, places to record the coordination, communication methods, and conditional status of requests. Based on the charts, we derived critical issues and possible problems in coordination and constructed questionnaires. We consulted with SMEs and AT supervisors to construct the AF questionnaire. To understand coordination from the AT side,

we also created a questionnaire for AT based on the AF questionnaire. After we constructed the questionnaires, we sent them to nine MCC AF supervisors and four AT supervisors in the field to ascertain that the content and format were acceptable. Based on their feedback, we revised the questionnaires.

As we constructed the questionnaires, we developed questions that directly tapped participants' knowledge. We minimized the number of open-ended questions to improve the ease of responding for the participants. The estimated completion time for each questionnaire was less than an hour.

Both AF and AT questionnaires had six parts:

1. The first part was an introduction to the survey. It described the purpose of the survey and explained that their participation was voluntary and their responses would be treated anonymously and confidentially.
2. The second part gave instructions on how to fill out the forms.
3. The third part asked the demographic questions.
4. The fourth part questioned the general characteristics of coordination between two groups. For instance, we asked them what were the critical factors for successful coordination.
5. In the fifth part, we asked them about their experience and opinions on coordination of specific maintenance events, that is, Scheduled, Unscheduled, and FI Events.
6. In the last part, we asked their opinions on the current coordination (i.e., if they had any obstacles in the current coordination and any suggestions for improving the current coordination process).

2.3 Procedure

Before we sent out the AF questionnaires, we coordinated them with the Professional Airway Systems Specialist (PASS) (i.e. AF union) and AF office. We planned to send questionnaires to AT supervisors for the AT side, therefore we needed the approval of managers only at the sites where we sent the questionnaires. At each AF and AT site, we had a POC who received a package of questionnaires from us and distributed them to volunteer participants. We enclosed pre-paid, self-addressed envelopes with the questionnaires, so participants could mail the questionnaires to us directly. On March 8, 2001, we finished mailing out all questionnaires. After 4 weeks, we reminded the POCs to ascertain that the questionnaires were completed and returned to us. We closed the window of collecting data on May 25, 2001.

3. Results

The detailed results of each question are provided in Appendices C for AF, D for AT, and E for open-ended questions for both AF and AT. We will present the summary of results under the following subheadings:

1. AT and AF demographic characteristics.
2. Time of coordination.
3. Information and communication in coordination.
4. Mutual understanding.

5. Distributing responsibilities and empowering.
6. Notification and responsiveness.

The number of respondents to questions varied because not all participants responded to each question. The possible maximum numbers were 95 for AF and 179 for AT. The numbers in the parentheses in the following graphs are the number of participants who responded to that particular item of the question. Usually, the number of participants who responded to "Other" is small. Because of that, we did not analyze it unless there were any significant facts to report. We did not use it for testing.

Also, in the following graphs for rank data, even though respondents used smaller numbers to designate higher ranks (such as 1 as the highest), we showed high ranks as high bars in the graphic representation. For this purpose, we subtracted the raw ranks from the total number of items in the question and used these new numbers for graphic representation. We ordered the items by rank on the x-axis.

All tests (Mann-Whitney U test and *t* test) were done using SPSS 10.1 version (SPSS, Inc., 2000). We used Mann-Whitney U test when we compared categorical data of two groups. We used *t* test when we could use individual respondents' data of two groups directly.

3.1 Demographic Information

We mailed out 652 forms (282 AF and 370 AT forms) and received 283. This represents a 43 % of the total survey forms sent out. Among them, we could not use nine forms for various reasons. We analyzed 95 AF and 179 AT forms, totaling 274 forms. If we consider these analyzed forms only, the return rates were 34% for AF and 48% for AT.

3.1.1 AF Demographic Characteristics

We sent out forms to randomly chosen 12 AMCCs and 12 GMCCs. Among the 95 AF respondents, 56 belonged to AMCCs, 31 to GMCCs, and 8 were unknown.

Eighty-seven participants responded to the question addressing their job position. Most of them were either MCC specialists (53%) or NOMs (40%). According to the FAA order (FAA, 1999b), MCC specialists for AMCC and GMCC are responsible for coordination with AT, but in reality, other people such as field technicians and NOM supervisors may coordinate as shown in Table 1.

Table 1. Job Positions of AF Respondents

Job Position	MCC Specialists	NOM	Field Technicians	NOM Supervisor
Frequency (n= 87)	46 (53%)	35 (40%)	5 (6%)	1 (1%)

We collected the data of their work experience at the current MCC position, other previous MCC positions, and other AF positions. The average numbers of work years of the 86 respondents to this question are shown in Table 2. On average, they worked at their current position for 5 years and 7 months. Sixty-six percent of the respondents had less than 6 years of experience in their current position. Their average number of working years in AF was 21 years. The standard deviations (*SD*) are large as shown in Table 2.

Table 2. AF Respondents' Years of Experience at the Current AF Position, Other MCC Positions, and Other AF Positions

Statistics	Current position at MCC	Previous Positions at MCC	Other AF Positions
Mean (years) (n=86)	5.6 (*SD*: 4.8)	1.1 (*SD*: 2.9)	14.2 (*SD*: 8.1)

The left graph of Figure 1 presents the distribution of the number of years each respondent worked for the present MCC position. The right graph shows the total years each person worked in AF. Both graphs were drawn after sorting participants by year of work experience. For instance, the right-most respondent is the one who worked longest.

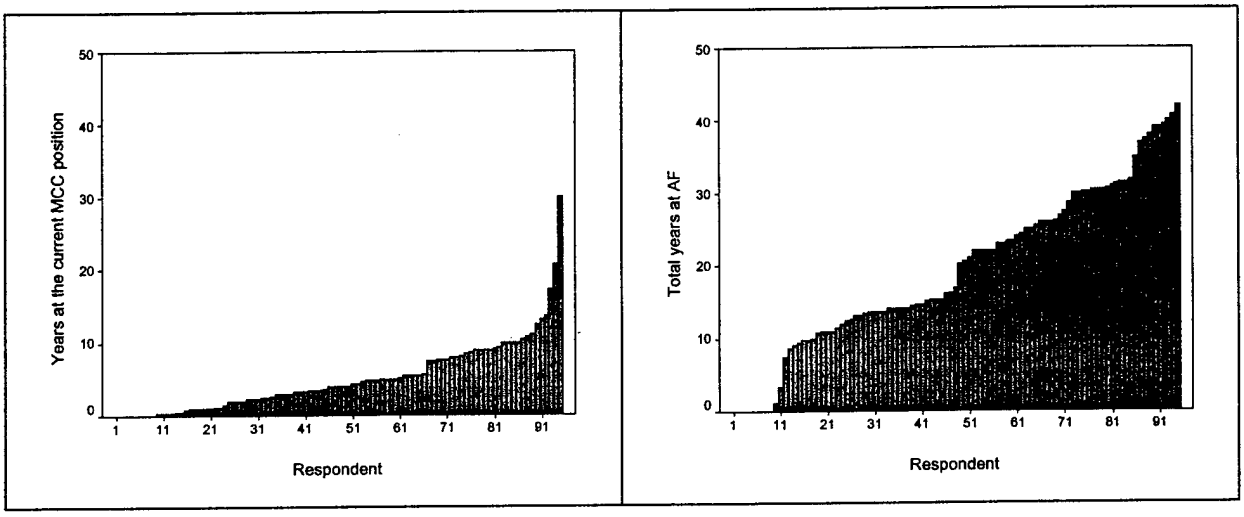


Figure 1. Years of work experience in the current AF MCC position (left) and total years of working in the AF (right).

3.1.2 Air Traffic Demographic Characteristics

Among 179 AT respondents, there were 107 Operations Supervisors (OSs), 58 Operations Managers (OMs), and 14 unknowns. The OS "directs a staff of ATCSs who are responsible for carrying out air traffic control assignments within a limited geographic area" (FAA, 2001b, p.1). The OM is the manager of the facility and "directs a highly technical workforce that provides either air traffic control services and/or tactical and strategic support" (FAA, 2001c, p. 1). The average number of years in the current position for these AT supervisors was 7 years and 8 months. Figure 2 shows the distribution of years of experience for each respondent.

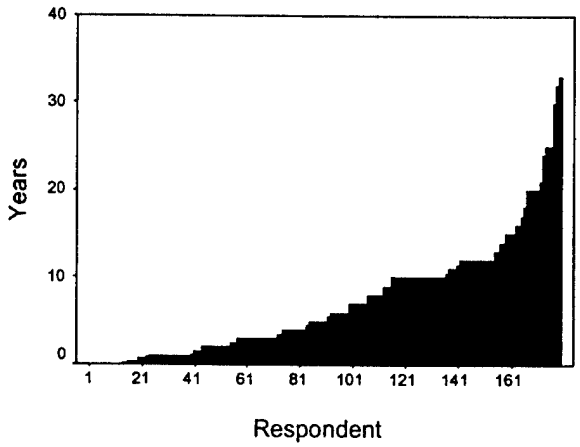


Figure 2. Years of AT respondents' work experience at the current position.

3.2 Time of Coordination

For both AF and AT, coordination occurs at any time of the day, but, for both AF and AT, it occurs in the morning between 6 a.m. and 12 p.m. most often (Figure 3).

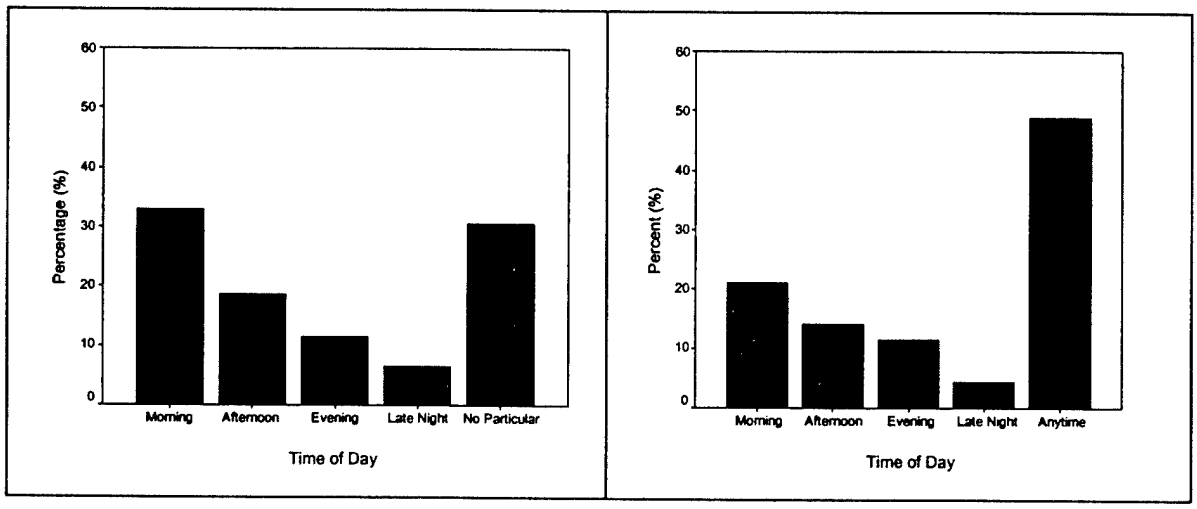


Figure 3. Coordination time of day for AF (left graph) and AT (right graph).

3.3 Information and Communication in Coordination

The major purpose of coordination is getting and disseminating information efficiently. This efficiency depends on a few factors such as information sources, information content, information quality, and communication method.

3.3.1 Information Sources

Overall, when AF respondents coordinated, they contacted AT ARTCC personnel (Item 13) most often as shown in Figure 4. The next group they contacted often was AF field technicians (Item 2). They contacted other AT personnel (Items 9 and 10) and AF personnel at other facilities (Item 11) more often than personnel at the rest of the other organizations.

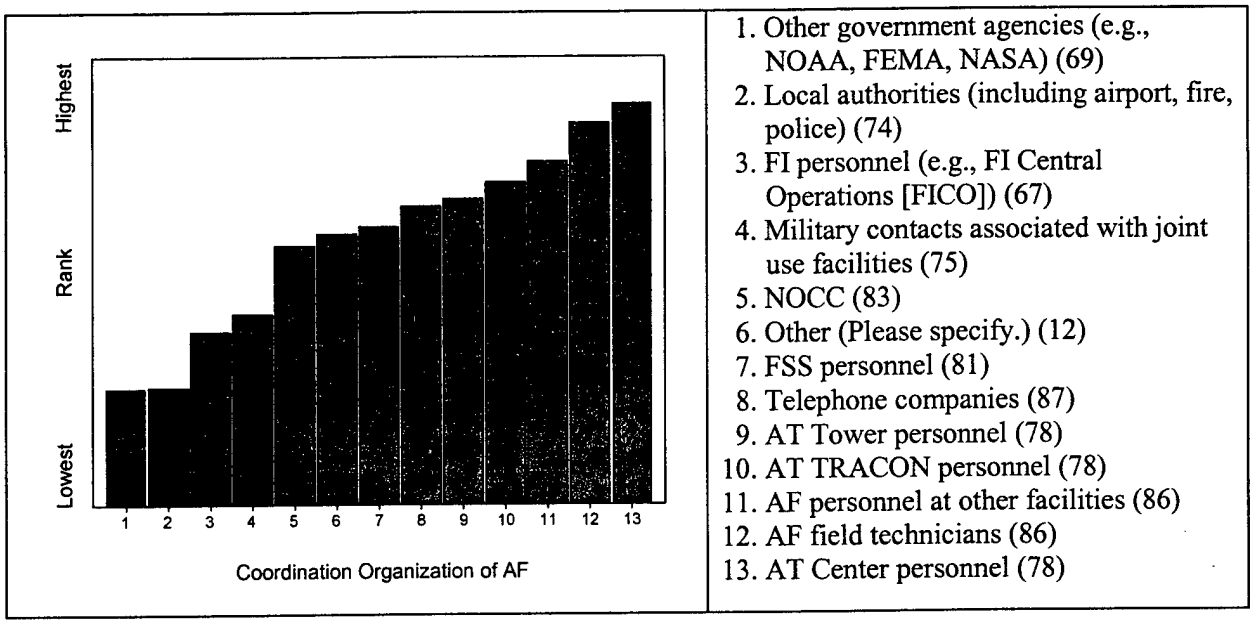


Figure 4. Ranks of contact frequency of various organizations by AF personnel (AF: Section A, Question 1).

When the data were divided into AMCC and GMCC, the contact patterns were different to some extent between the two organizations (Figure 5). AMCC personnel coordinated with the AT center personnel (Item 13) and GMCC personnel coordinate with AF technicians (Item 12) most often, respectively. All items except Items 1 (other government agencies) ($p = .439$) and 2 (local authorities) ($p = .197$) were significantly different between AMCC and GMCC (Mann-Whitney U test, $p < .05$).

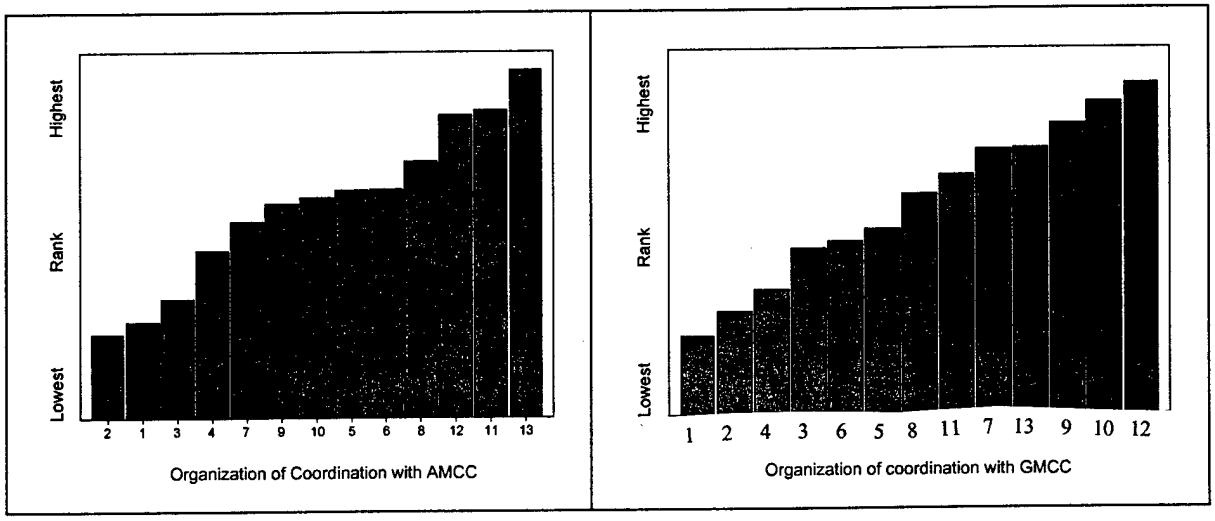


Figure 5. Rank of contact frequency of organizations by AMCC and GMCC (AF: Section A, Question 1).

For the task of closing FIs, AF respondents coordinated with FSS and field technicians most often (see detailed results of AF: Section D, Question 3 in Appendix C). In addition, as shown in

Figure 6, the three most problematic factors for AF in coordination were about information sources: information quality (Item 9), timely delivery (Item 8), and too many groups to coordinate with (Item 6) (see detailed results of AF: Section A, Question 3 in Appendix C).

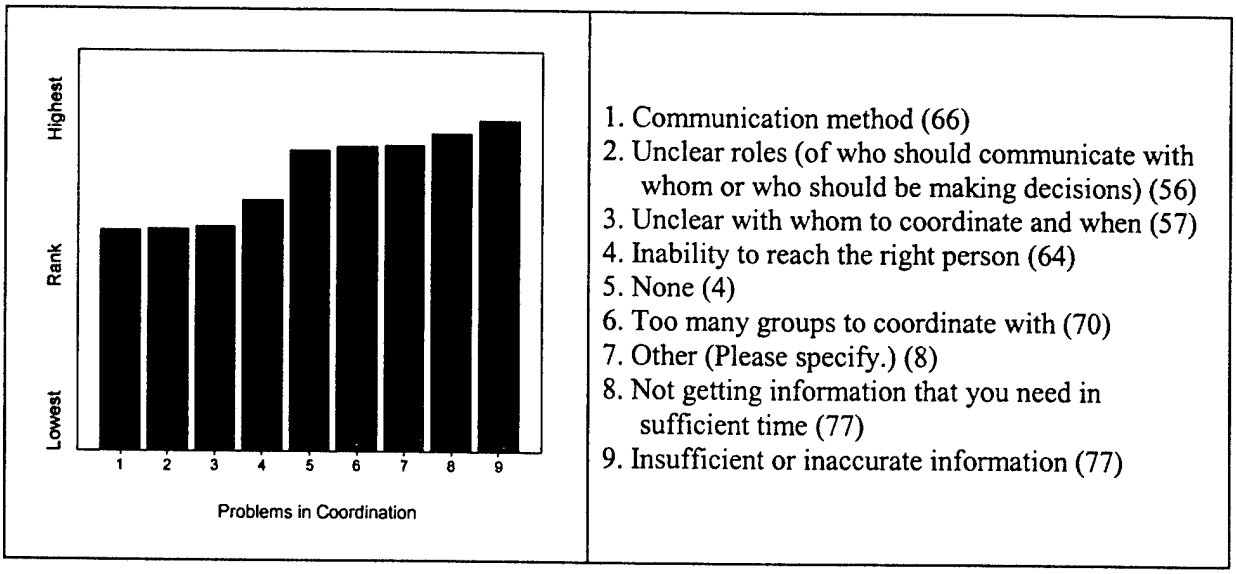


Figure 6. Problems AF currently face with coordination (AF: Section A,Question 3).

Some respondents expressed that to have a successful coordination, it is critical to easily find the right person with whom to coordinate and have one POC (see the summary of participants' responses to open-ended questions in Appendix E).

To find out with whom to coordinate, AF respondents used both electronic forms and their past experience and training equally often (see detailed results of AF: Section A, Question 5 in Appendix C). AT respondents relied upon their past experience and training more than any other memory aids (see detailed results of AT: Section A, Question 5 in Appendix D).

There are many facets of information source, and one of them is staffing. If there are not enough staff to coordinate, the information dissemination may be delayed, or the coordinator may not be at the desk to receive the information. As the most critical obstacle to efficient coordination (see detailed results in Appendix E: Obstacles), AT respondents indicated the low staffing at AF and their availability. AF respondents also expressed the same concern (see detailed results in Appendix E: Obstacles). AT respondents strongly suggested the increase of AF staff to make coordination better (see detailed results in Appendix E: Suggestions).

3.3.2 Information Content

We asked AF and AT personnel a few questions about what information they collected and disseminated during coordination. The questions belonged to four different categories: General, Scheduled Events, Unscheduled Events, and FIs.

3.3.2.1 General

We asked AF personnel if they provided AT with the information about the current and expected traffic conditions, weather conditions, chances for approval at the requested time, availability of alternative times, required backup systems, and special events. We asked AT personnel if AF provided them with the same information. Both of the groups responded that this information

was exchanged more than 50% of the time. Both responded that they provided the information of the chances for approval at the requested time more often than any other information mentioned above (see detailed results of AF: Section A, Question 10 in Appendix C and AT: Section A, Question 7 in Appendix D).

AF respondents relied on their training, experience, and electronic forms equally often to memorize what information to use for coordination and with whom to coordinate (see AF: Section A, Questions 4 and 5 in Appendix C). AT respondents, however, used training and experience more often than electronic forms for both occasions (see AT: Section A, Questions 3 and 4 in Appendix D).

Even though the rank of "Using the same terminology" was not very high for both AF (see detailed results of AF: Section A, Question 2 in Appendix C) and AT (see detailed results of AT: Section A, Question 1 in Appendix D) in answering the question on the critical factors for effective coordination, it was ranked highest after the information-related factors. One AF and seven AT respondents expressed it (i.e., not using the same terminology) as an obstacle for efficient coordination (see detailed results of the open-ended question in Appendix E: Obstacles).

a. Releasing Service

When AF personnel request that AT release a service, they need to provide enough information so that AT can decide on their concurrence with AF. AF respondents identified that the most frequently provided information were "date and time of event being coordinated" (97%) and "expected duration of event being coordinated" (97%) (see the detailed results of AF: Section A, Question 9 in Appendix C). AT respondents also thought that these information were the most frequently provided information from AF to them (91% and 90%, respectively) (see the detailed results of AT: Section A, Question 8 in Appendix D).

b. Prioritization

AF personnel need to prioritize tasks depending on their workload and situation urgency. They responded that the air traffic information was the most important in prioritizing their tasks (see the detailed results of AF: Section A, Question 6 in Appendix C). However, they responded that, in general, AT personnel did not prioritize AF maintenance tasks. On average, they gave the scale value 3.4 when they were asked to scale the frequency of AT prioritization between 1 and 10, where 1 = never and 10 = always (see the detailed results of AF: Section E, Question 7 in Appendix C).

c. Beneficial Information

We asked AF personnel if there was any information that was not currently provided to AT but would benefit coordination. Even though their response rate was low for this question, they thought the information of technicians' travel time would benefit coordination (see the detailed results of AF: Section A, Question 12 in Appendix C). This was also the information AT respondents mentioned most for the same question (see the detailed results of AT: Section A, Question 9 in Appendix D). Not many AF respondents answered the question on the additional information from AT that was not currently provided but would be beneficial for coordination. Nevertheless, 26 AF respondents thought the real-time depiction of aircraft flow would be beneficial (see the detailed results of AF: Section A, Question 11 in Appendix C).

3.3.2.2 Scheduled Events

Just before the release of Scheduled Events, AF personnel ask AT about the previously approved schedule, an alternative time, and the necessary arrangement made for available back-up systems (AF: Section B, Question 1). We gave the same list to AT personnel and asked them what information AF collected from them (AT: Section B, Question 1).

As shown in Table 3, most AF and AT respondents exchanged information about the schedule. The information about the back-up system was not exchanged as often (see the detailed results of AF: Section B, Question 1 in Appendix C and AT: Section B, Question 1 in Appendix D).

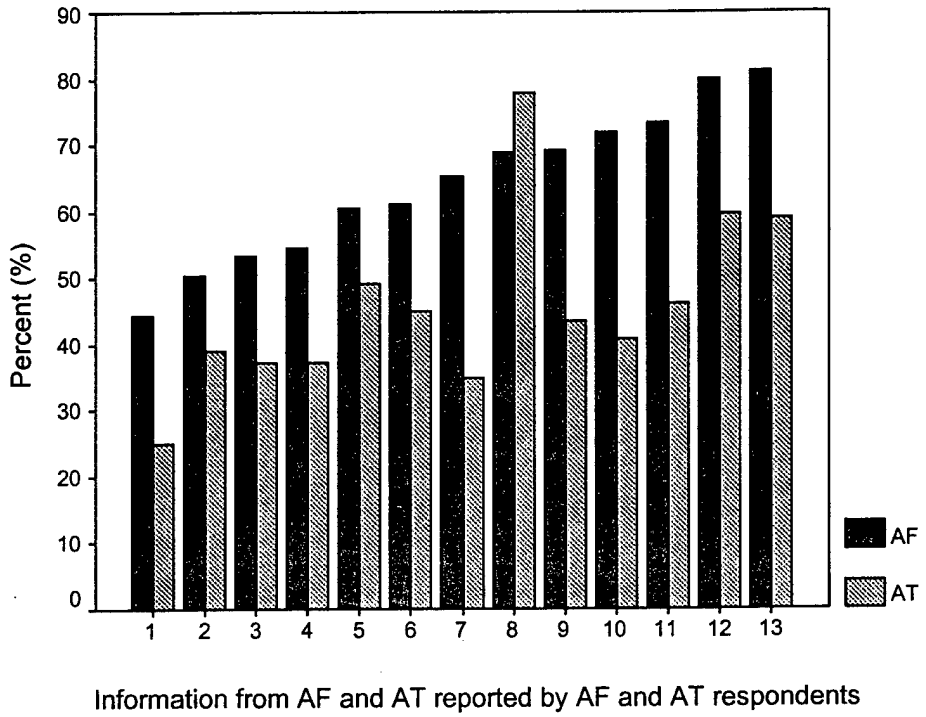
Table 3. Percent of AF and AT Respondents Who Thought AF Provided AT With the Information Before Releasing Service During Scheduled Events

Group	Is the previously approved schedule still good?	If the approved schedule is not good, is there alternative time available?	Has AT made the necessary arrangement to use any available back-up systems?
AF	93%	87%	54%
AT	80%	67%	21%

3.3.2.3 Unscheduled Events

For Unscheduled Events coordination, AF respondents provided AT with information about what equipment and services (Item 12) were affected 80% of the time and the cause of event (Item 13) 81% of the time (AF: Section C, Question 1). AT responded that AF provided the information about the expected restoration time (Item 8) most often, 78% of the time (Figure 7) (AT: Section C, Question 1).

To test if AF personnel with more work experience may provide information to AT differently (AF: Section C, Question 1), we divided the AF respondents. Using their median years of experience (4.5 years), we divided the AF respondents into two equal groups, that is, more experienced (equal to or more than 4.5 years) and less experienced (less than 4.5 years). The overall patterns of information dissemination by the two groups were similar. Mann-Whitney-U test showed that these two groups were not significantly different on any information ($p > .05$) (see detailed results of AF: Section C, Question 1 in Appendix C).



	AF	AT
1. Other	(9)	(8)
2. Availability of staff if an alternate time is needed	(91)	(169)
3. Frequency of status updates	(90)	(166)
4. Availability of technicians with necessary skills	(93)	(169)
5. Activities needed to restore	(92)	(170)
6. Status of needed parts (e.g., availability)	(94)	(168)
7. Status of adjacent facilities	(93)	(170)
8. Expected restoration time	(93)	(174)
9. When are the other facilities expected to be returned to service?	(93)	(168)
10. Status of technicians	(92)	(170)
11. Are there other events scheduled that this event would impact?	(92)	(171)
12. Equipment and services affected	(90)	(173)
13. Cause of event	(93)	(171)

Figure 7. The percentage of time AF provided unscheduled events information to AT according to AF and AT respondents.

3.3.2.4 Flight Inspections

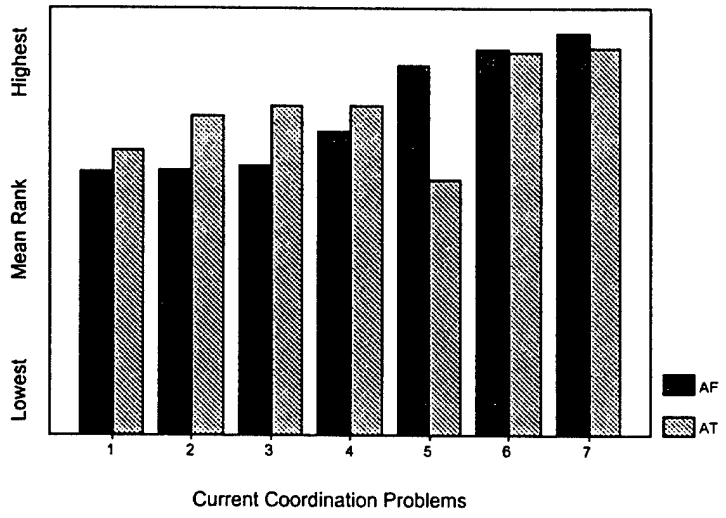
For FI coordination, AF respondents indicated that they provided AT with the time of the FI, information of the facility, identifiers, and runway numbers about 80% of the time (see the detailed results of AF: Section D, Question 1 of Appendix C). AT respondents answered similarly (see the detailed results of AT: Section D, Question 1 of Appendix D).

AF respondents reported that AT provided them with the information of expected traffic conditions at the time of scheduled FI 48% of the time, effect on traffic flow 49% of the time, availability of AT respondents to help FI, if needed 32% of the time, and the possibility of

interrupting FI 40% of the time (see the detailed results of AF: Section D, Question 3 of Appendix D). AT respondents answered that they provided AF with the information about 66%, 65%, 38%, and 60%, respectively (see the detailed results of AT: Section D, Question 2 of Appendix D). To close out FI events, AF respondents coordinated most often with FSS personnel and AF field technicians (see the detailed results of AF: Section D, Question 3 of Appendix C).

3.3.3 Information Quality

Even though AF and AT respondents did not mention that information quality was a critical coordination problem (see Appendix E), they ranked insufficient or inaccurate information and not getting information needed in sufficient time (AF: Section A, Question 3, Item 1 and AT: Section A, Question 2, Item 1) as the highest ranked problems (Figure 8).



	AF	AT
1. Communication method	(66)	(88)
2. Unclear roles (of who should communicate with whom or who should be making decisions)	(56)	(79)
3. Unclear with whom to coordinate and when	(57)	(78)
4. Inability to reach the right person	(64)	(77)
5. Too many groups to coordinate with	(70)	(63)
6. Not getting information that you need in sufficient time	(77)	(99)
7. Insufficient or inaccurate information	(77)	(115)

Figure 8. Current problems in coordination perceived by AF and AT.

3.3.4 Communication Method

To exchange information, coordinators used a few different communication methods. According to the research, the face-to-face communication was the most effective communication method (Smith et al., 1998; Warkentin et al., 1997). Overall, AF respondents used the telephone most

often and used the face-to-face method quite often (Question 7 in Appendix C) (Figure 9). AT respondents used the face-to-face method most often (Question 5 in Appendix D) (Figure 9).

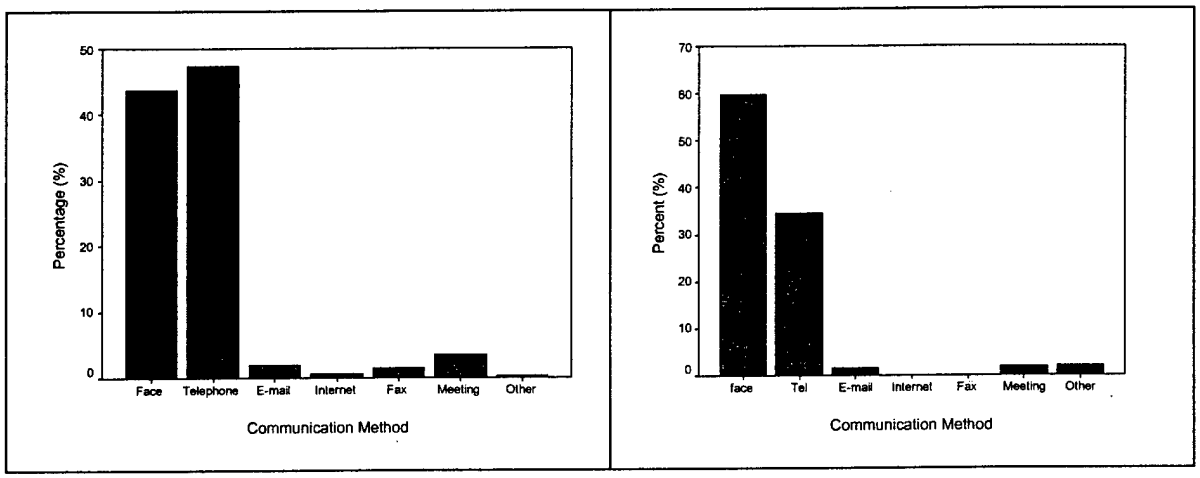


Figure 9. Communication methods of AF (left) and AT (right).

These usage frequencies seemed to depend on the work environment as shown in Figure 10. The respondents of AMCCs, which were collocated with ARTCCs, communicated face-to-face most often. This contrasts with the communication methods of respondents at GMCCs that are not always collocated with AT facilities, who used telephones extensively. The Mann-Whitney U test showed that AMCC and GMCC were significantly different in using the communication methods of face-to-face ($p < .01$), telephone ($p < .01$), and Internet ($p < .05$). There was no significant difference for other communication methods between the two groups.

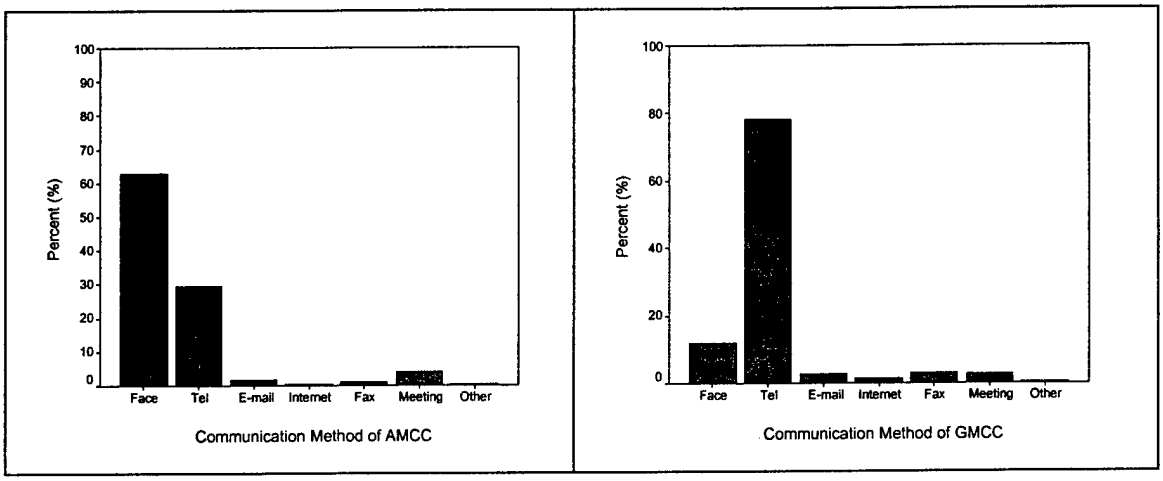


Figure 10. Communication methods of AMCC (left) and GMCC (right).

3.4 Mutual Understanding

Converse et al. (1991), Langan-Fox et al. (2000), and Smith et al. (1998) argued that a shared mental model helps coordination be effective. To test this, we asked AF personnel if they understood AT tasks and responsibilities and how thoroughly AT personnel understood their

roles and responsibilities (Section E, Question 9 of AF Questionnaire). Their ratings were 7.6 and 6.0, respectively (Figure 11). We asked AT personnel the same question about AF (Section E, Questions 5 and 6 of AT Questionnaire). Their ratings were 6.6 and 6.4, respectively (Figure 12).

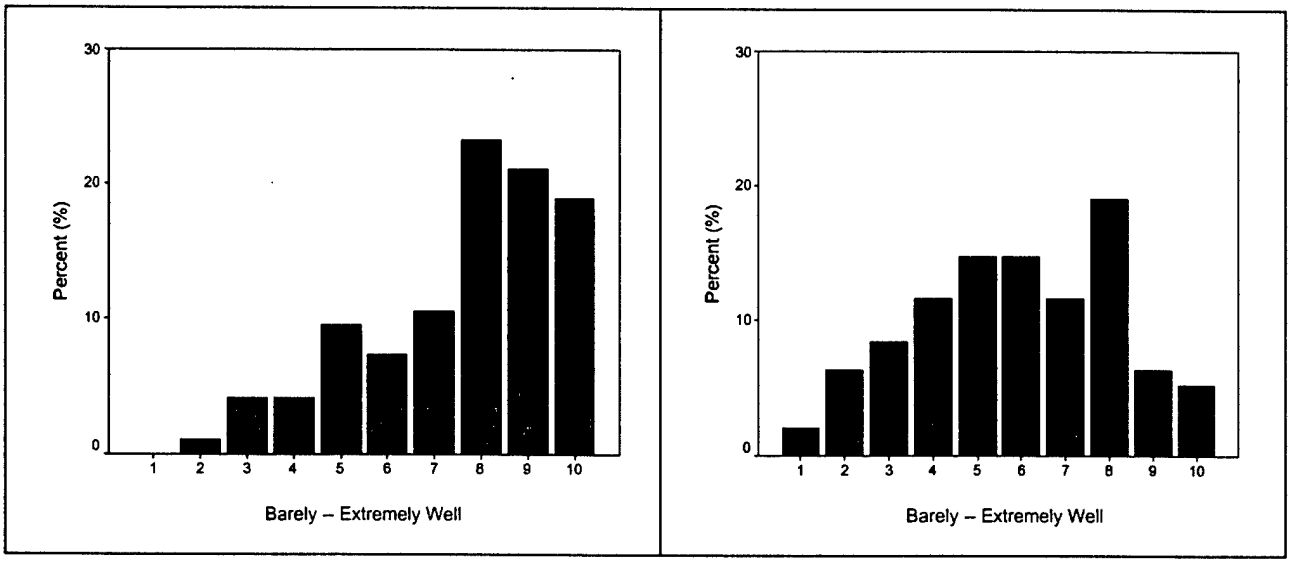


Figure 11. AF respondents' understanding of AT tasks and responsibilities (graph at the left) (mean: 7.6) and their assumed AT understanding AF tasks and responsibilities (graph at the right) (mean: 6.0).

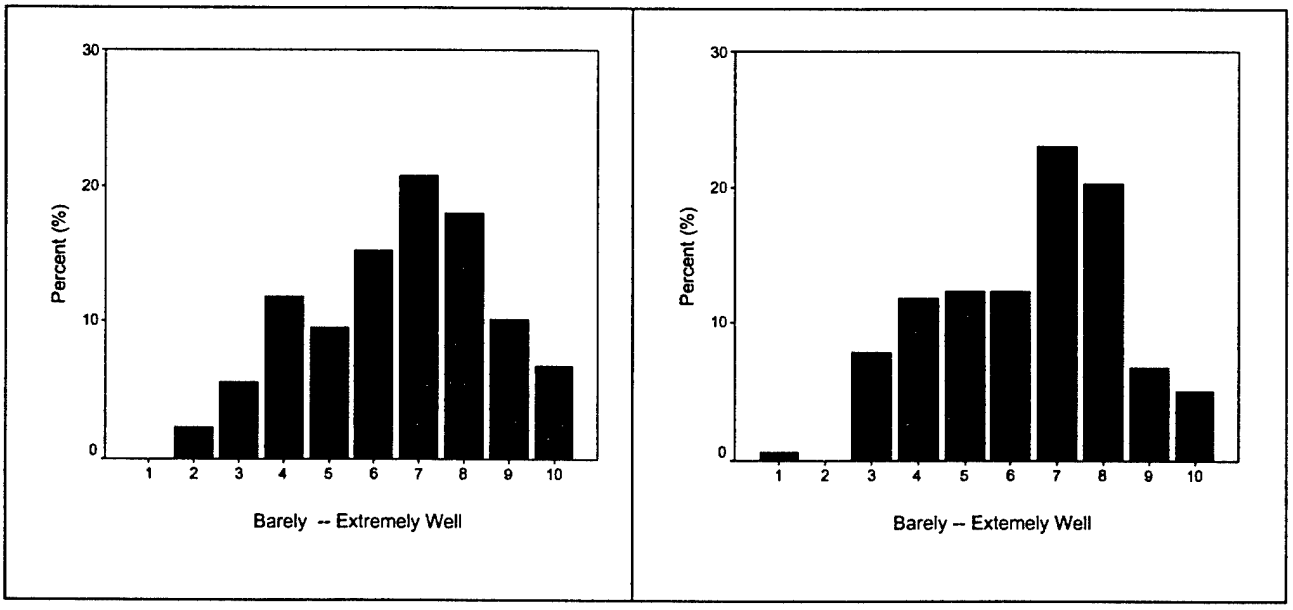


Figure 12. AT respondents' understanding of AF tasks and responsibilities (graph at the left) (mean: 6.6) and their assumed AF understanding AT tasks and responsibilities (graph at the right) (mean: 6.4).

To the open-ended questions, both AF and AT responded that understanding each other was one of the most successful aspects (11 AF respondents and 6 AT respondents). Thirteen AT respondents thought that AF's lack of understanding AT tasks and knowing AF jobs was an obstacle for efficient coordination (see Appendix E).

3.5 Distributing Responsibilities and Empowering

Researchers claimed that to make coordination efficient, sometimes it is necessary to empower the other party and allow them to take initiatives (Eurocontrol, 1998; Lacher & Klein, 1993; MacDonald, 1998; Smith et al, 1998). We asked AF personnel how often AT personnel prioritize their tasks (Figure 13). The mean rating was 3.4. This means the AT respondents seldom prioritized AF tasks.

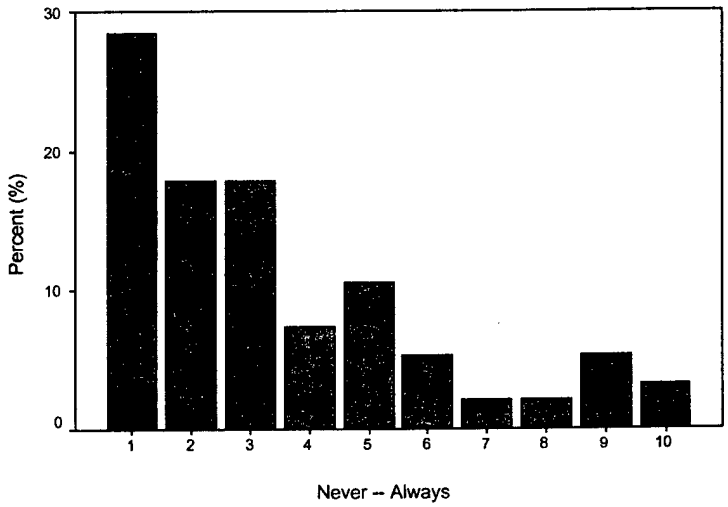


Figure 13. Ratings on the frequency of AT prioritizing AF tasks.

3.6 Notification and Responsiveness

For efficient coordination, each participating organization should promptly respond to the other's requests. For the statement of "Current response times to maintenance requests are adequate" (AF: Section E, Question 1), AF respondents gave a mean rating of 7.0 (1 = Never and 10 = Always).

For the open-ended questions, 12 AF respondents mentioned that some AT personnel were slow on approvals and reluctant to release systems. These were obstacles for efficient coordination. Seven AT respondents expressed that responsiveness was important to make coordination successful (see Appendix E).

For Scheduled Events, we asked AF personnel how far in advance they notified AT of maintenance and how soon they received approval or disapproval (AF: Section B, Questions 3, 4, 5, and 6). We also asked AT personnel similar questions (AT: Section B, Questions 3, 4, 5, and 6). Table 4 summarizes the results, which show that AF respondents' notice and response times were longer than those that AT respondents claimed to be.

Table 4. Mean Lead Time of Notice by AF and Response Time of Approval or Disapproval by AT for Scheduled Events

Respondents	AF to AT Lead Time of Advance Notice		AT Response Times for Approval or Disapproval	
	Short-Term	Long-Term	Short-Term	Long-Term
AF	1 day, 10 hr, 20 m	8 days, 8 hr, 14 m	6 hr, 27 m	12 days, 5 hr, 9 m
AT	1 day, 5 hr, 36 m	5 days, 6 hr, 39 m	5 hr, 22 m	1 day, 12 hr, 30 m

We divided AF respondents into two groups by years of experience at the current position using their median years (4.5 years) to see if work experience matters in this issue. We categorized respondents as more experienced when their experience years were equal to or longer than 4.5 years and less experienced when theirs were less than 4.5 years. We examined the data to determine if the groups differed in time to send advance notices to AT for the upcoming short-term (less than 5 hours to complete) and long-term Scheduled Events (5 or more hours to complete). The results showed there was no significant difference between the two groups for either short-term ($p > .05$, Mann-Whitney U test) or long-term ($p > .05$, Mann-Whitney U test). Actually, for both short-term and long-term Scheduled Events, the less experienced AF respondents gave longer advanced notices to AT than the more experienced. The mean notice times for the short-term events were 1 day, 14 hours, 12 minutes for the less experienced and 1 day, 6 hours, 18 minutes for the more experienced. For the long-term events, the mean notice timers were 9 days, 8 hours, 26 minutes for the less experienced and 7 days, 16 hours, 15 minutes for the more experienced.

3.7 Open-Ended Questions

AF and AT respondents indicated that their working relationship was the most important *factor for successful coordination* (Figure 14). The next most successful aspect was face-to-face communication.

They also thought that the worst *obstacle of the current coordination* was the information source (Figure 15). Sometimes, they had difficulty finding the right person with whom to coordinate. For AF respondents, the next obstacle was slow AT responses. For AT respondents, the low staffing at AF was the most serious obstacle.

Not many AF and AT respondents expressed *opinions on how to improve the current coordination processes* (Figure 16). For AF, local control, knowing the other's needs and responsibilities, and communication methods were suggested most. For AT, staffing, information source, knowing the others, and local control were suggested more often than others.

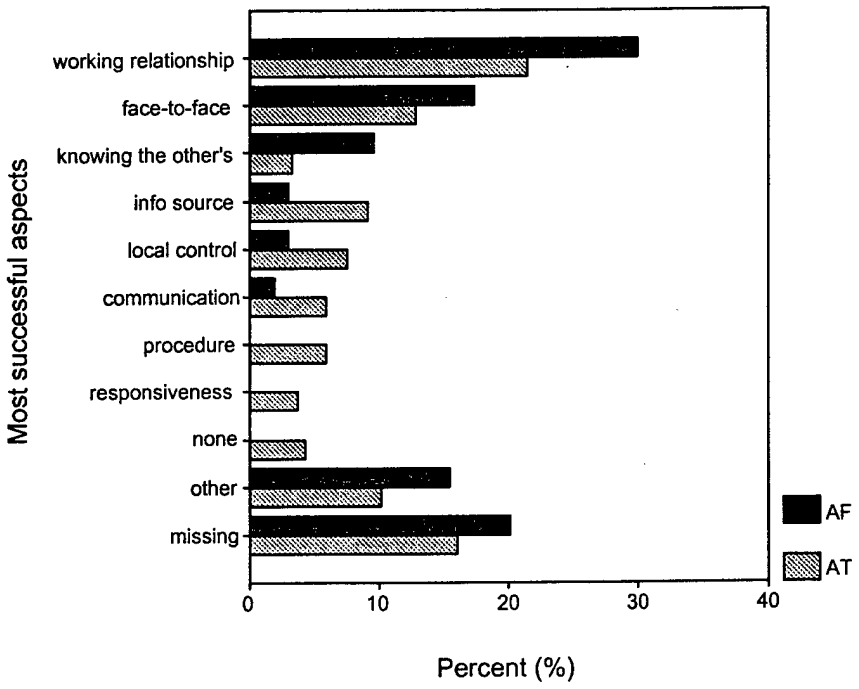


Figure 14. The most successful aspects in coordination as perceived by AF and AT respondents.

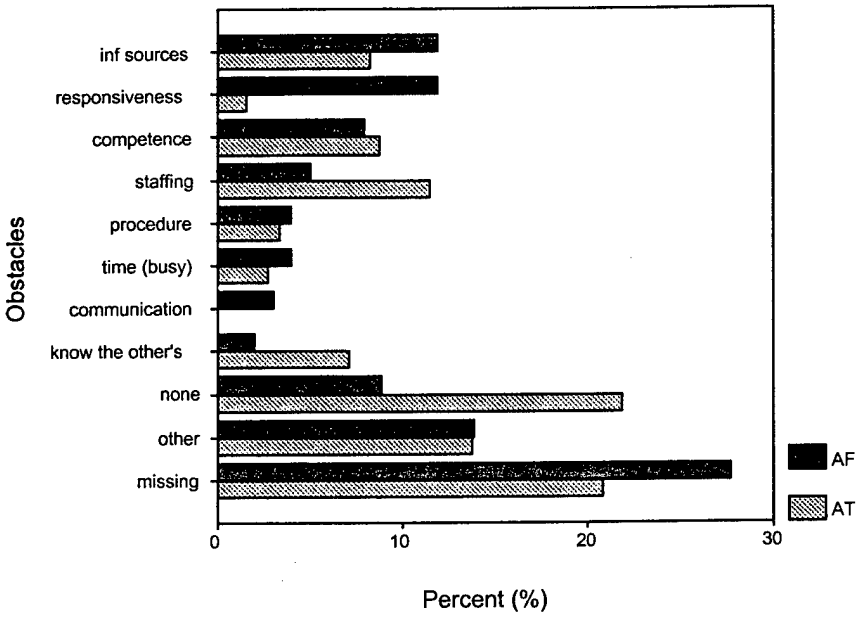


Figure 15. Obstacles to efficient coordination as perceived by AF and AT respondents.

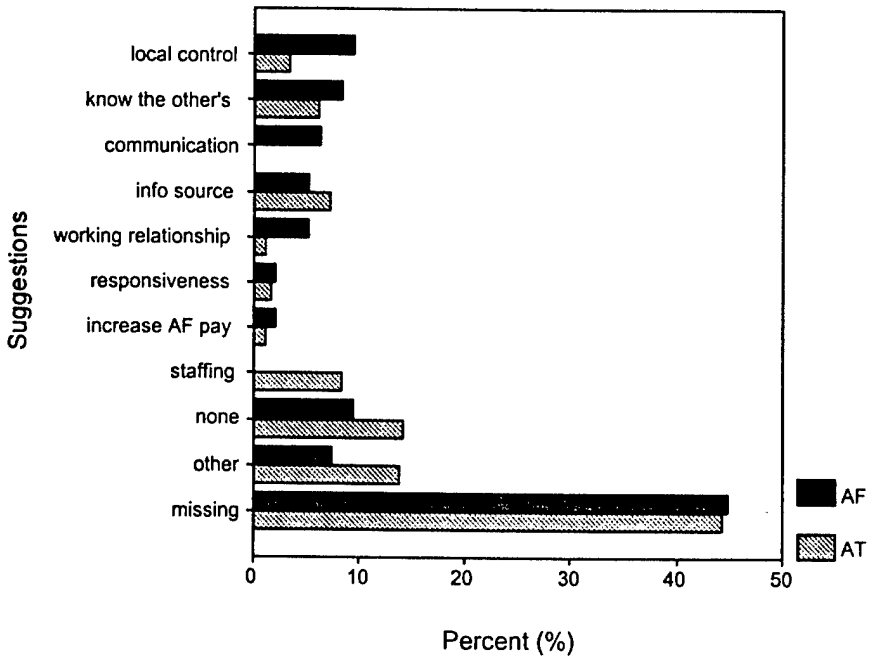


Figure 16. AF and AT respondents' suggestions to improve the current coordination process.

3.8 AMCC vs. GMCC and ARTCC vs. non-ARTCC

AMCCs are collocated with ARTCCs. Because of this collocation, AMCC and ARTCC respondents might have more efficient coordination than other respondents. In the following sub sections, we present their differences on relevant questions on this issue (see Appendix E).

3.8.1 AMCC vs. GMCC

As shown in Table 5, AMCC and GMCC respondents had significantly different opinions on critical coordination issues. We speculate that this may be due to AMCCs' collocation with ARTCCs.

Table 5. AMCC and GMCC respondents' opinions on critical coordination issues and statistical results on their differences of opinions

Questions	AMCC		GMCC		*t*	*p*
	Mean	Standard Deviation	Mean	Standard Deviation		
Current response times to maintenance requests are adequate. (AF: Section E, Question 1) (1 = Strongly disagree, 10 = Strongly agree)	7.7	1.9	5.8	2.4	3.74 (*df*=51)	< .01
There are clearly defined roles for coordinating with AT. (AF: Section E, Question 2) (1 = Strongly disagree, 10 = Strongly agree)	7.8	2.2	6.5	2.5	2.55 (*df*=85)	< .05
How thoroughly do you understand AT tasks and responsibilities? (AF: Section E, Question 8) (1 = Barely, 10 = Extremely well)	8.2	1.7	6.6	2.2	3.40 (*df*=85)	< .01
How thoroughly do you think AT personnel understand your roles and responsibilities? (AF: Section E, Question 9) (1 = Barely, 10 = Extremely well)	6.3	2.1	5.2	2.4	2.29 (*df*=85)	< .05
How successful is current AT/AF coordination? (AF: Section E, Question 10) (1 = Not successful, 10 = Extremely successful)	8.5	1.2	7.3	1.7	3.68 (*df*=46)	< .01

3.8.2 ARTCC vs. non-ARTCC

To check further that close proximity and face-to-face communication may contribute to better coordination, we performed similar analyses with AT data. As ARTCCs are collocated with AMCCs, ARTCC supervisors must coordinate often with AMCC AF personnel in face-to-face communication.

As shown in Figure 17, ARTCC respondents used face-to-face communication extensively (65%) as opposed to Non-ARTCC respondents (47%). ARTCC respondents used telephone communication about 30% of the time and non-ARTCC respondents used it about 49% of the time. ARTCCs are collocated with AMCC.

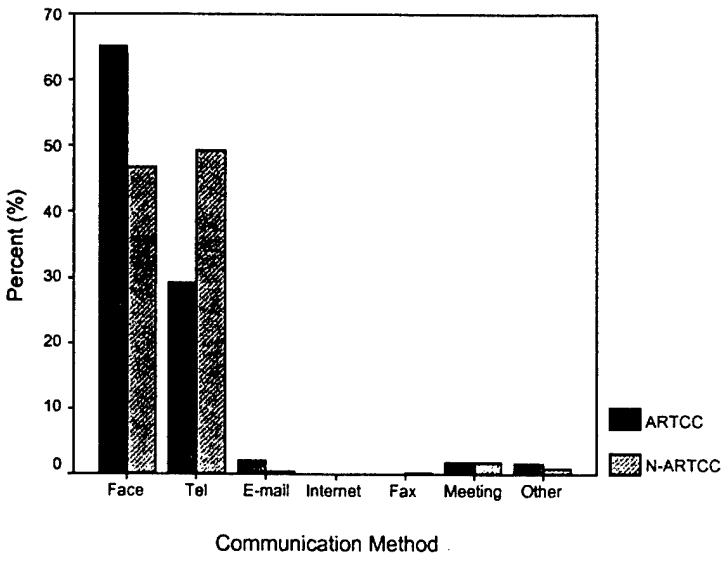


Figure 17. Communication methods by ARTCCs and Non-ARTCCs respondents.

Even if the non-ARTCC respondents did not use the telephone more extensively than the face-to-face communication method, their opinions on coordination still may be different from ARTCC respondents'. In the following, we compared their results on answers to questions about their coordination with AF. As shown in Table 6, ARTCC and non-ARTCC respondents' opinions on any of critical coordination issues were not significantly different.

It is not clear why we did not get similar results with AT data as with AF data (Table 5 vs. Table 6). This may be due to the fact that the frequency difference between ARTCC's and non-ARTCC's usage of face-to-face communication was not as large as the frequency difference between AMCC's and GMCC's usage (Figure 17 vs. Figure 10).

4. Discussion

There are several major influential issues for efficient coordination: information source, information quality, terminology, communication method, timely notice and responsiveness/feedback, competent personnel, common mental model including understanding the other's needs and requirements, and empowering. Our questionnaires touched all of these issues. However, this research is a baseline study of AF and AT coordination, and we lack data to present a thorough and clear picture of some major issues. For instance, Eurocontrol (1998) researchers thought empowering was good for efficient coordination. We asked AF personnel how often AT personnel prioritized AF maintenance tasks. Our results showed that according to AF respondents, AT personnel did not prioritize often. The average rating was 3.4 with 1 = Never and 10 = Always (see detailed results in AF: Section E and Question 7 of Appendix C). The largest number of AF respondents (28%) selected Rating 1 (Never). The number of the AF respondents who rated 1, 2, and 3 were about 64%. From our data, we cannot tell if this is desirable or not for efficient AF and AT coordination. A new study on this issue may shed light on this issue. In the following, we discuss the major issues separately.

Table 6. ARTCC and Non-ARTCC respondents' opinions on critical coordination issues and statistical results on their differences of opinions

Questions	ARTCC		Non-ARTCC		*t*	*p*
	Mean	Standard Deviation	Mean	Standard Deviation		
There are clearly defined roles for coordinating with AF. (AT: Section E, Question 1) (1 = Strongly disagree, 10 = Strongly agree)	6.9	2.6	6.3	3.1	1.12 (df=74)	> .05
How thoroughly do you understand AF tasks and responsibilities? (AT: Section E, Question 5) (1 = Barely, 10 = Extremely well)	6.6	1.9	6.3	2.3	.38 (df=165)	> .05
How thoroughly do you think AF specialists understand your roles and responsibilities? (AT: Section E, Question 6) (1 = Barely, 10 = Extremely well)	6.5	1.9	6.2	2.1	.83 (df=165)	> .05
How successful is current AT/AF coordination? (AT: Section E, Question 7) (1 = Not successful, 10 = Extremely successful)	7.9	1.9	7.2	2.2	1.87 (df=165)	> .05

4.1 Information

There are many facets of information-related issues (e.g., finding the information source; content; and quality; receiving a timely notice; sharing/exchanging information; communicating method; and different terminology between two groups). The data clearly showed that there were information-related problems.

AF and AT respondents ranked the two information-related problems highest (i.e., insufficient or inaccurate information and not getting information that they need in sufficient time) (AF: Section A, Question 2). For AF respondents, the third-highest ranked item was that they were unclear with whom to coordinate and when. They also cited the information-related obstacles most often in the open-ended question as the current obstacle. The numbers of information-related obstacles as expressed by AF and AT respondents to the open-ended question were 20 (27%) for AF respondents and 44 (30%) for AT respondents. If we do not include their responses of "None," the percents for the category were 31% for AF and 42% for AT.

The rating for the question of "Current response times to maintenance requests are adequate" (AF: Section E, Question 1) was 7.0 for AF respondents. We believe that this rating should have been higher if coordination is to be judged as efficient.

4.2 Procedure and Control

We asked AF and AT personnel if there were clearly defined coordination roles and responsibilities. Their average ratings were 7.3 and 6.7, respectively (1= strongly disagree; 10 = strongly agree) (AF: Section E, Question 2). We also asked AF personnel if there were mechanisms in place to detect inappropriate decisions in terms of acceptance and denial of requests for maintenance (AF: Section E, Question3). The average rating was 5.3. None of these ratings were high.

Four AF and six AT respondents also cited the lack of proper procedure as an obstacle for coordination. From these results, it is evident that the coordination procedure may not be clear to some personnel.

For the overall patterns in disseminating information during Scheduled Events coordination, both AF and AT groups were similar. However, more experienced AF respondents provided the information about the availability of back-up systems to AT more often than the less experienced AF respondents (84% vs. 69%). The Mann-Whitney U test showed that the group's difference on this was significant ($p < .05$). For all other information, there was no significant difference between the two groups. In addition, there were no significantly different patterns of AF respondents' disseminating information to AT between these two groups when they coordinated with AT respondents for Unscheduled Events (Mann-Whitney U test, $p > .05$). These results imply that even less experienced AF respondents could follow an established procedure without much difficulty when they disseminate information to AT.

To the open-ended question on improving current coordination, nine AF and six AT respondents suggested that the local control of coordination is important for efficient coordination. However, the MCC functions will be centralized and handled by the three Operations Control Centers (OCCs) (FAA, 1999a) in the future. This centralization will cause all data for coordination to be collected, maintained, and disseminated by the OCCs. The efficiency of coordination may depend largely on how well information is exchanged among coordinating units. However, to exchange information, there are other things that need to be established first. Knowing just the required information for a task is not enough for efficient coordination. Coordinators are not just information processors. They may need to diagnose the reported outage problems using the background information of the reports including the past outage history at the facility, characteristics of the facility, and the facility environment. The OCC specialists may have competent, specialized technical knowledge of the systems and equipment. However, they need to have common mental models and understand the other's needs, roles, and responsibilities as numerous researchers have claimed in the past (Converse et al., 1991; Eurocontrol, 1998; Lacher & Klein, 1993; Langan-Fox et al., 2000; MacDonald, 1998; Smith et al., 1998). We need to acknowledge these important factors for efficient coordination and incorporate them into the future centralized coordination of AF and AT by OCCs. It will be a daunting challenge for the FAA to accomplish, because the research results favor the local, face-to-face coordination. This issue may be studied in the future as a separate research project. One way to improve the faceless telephone communication may be to use videoconferencing.

4.3 Communication Method

Warkentin et al. (1997) reported that when coordination was done electronically, the members were less satisfied and experienced low team building. For our open-ended question about the most successful aspect of coordination, 18 AF (21%) and 24 AT (15%) respondents cited "face-to-face communication." This was mentioned most often after "working relationship" by both AF and AT respondents.

This face-to-face communication implies many aspects of communication. For instance, as they coordinate with each other in person, they receive instant feedback to their requests, obtain the information of the other's needs and requirements easily, build personal relationships easily, and get familiar with the other's personality.

4.4 Working Relationship

Respondents cited a good working relationship between AF and AT as one of the most successful aspects of the current coordination. Thirty-one AF respondents (37%) and 40 AT respondents (25%) mentioned that a good working relationship between them was the most successful aspect of the current coordination.

Eleven (13%) AF respondents and 6 (4%) AT respondents also cited that knowing each other's needs and responsibilities was another successful aspect of the current coordination between them. In the past, researchers also claimed that knowing each other and understanding the other's needs and responsibilities (or mental models) are important for the efficient coordination (Converse et al., 1991; Langan-Fox et al., 2000; Smith et al., 1998).

4.4.1 AMCC vs. GMCC in AF

For the question of "How thoroughly do you understand AT tasks and responsibilities?" (AF: Section E, Question 8), AF respondents gave the rating of 7.6 (1= barely; 10 = extremely well). For AT respondents, the rating was 6.0 for the question of "How thoroughly do you understand AF tasks and responsibilities?"

AF respondents gave the rating of 6.6 for the question of "How thoroughly do you think AT personnel understand your roles and responsibilities?" (1= barely; 10 = extremely well). For the same question about AF's understanding, AT rated it 6.4. From the two kinds of questions, it is possible that their mental models for the other organization were not well formed. From our data, it is not clear why they do not have clear mental models for the other group.

However, our data on the difference between AMCCs and GMCCs shed some light on this issue indirectly. AMCCs are collocated with ARTCCs. As summarized in Table 7, AMCC respondents gave more positive ratings to coordination than GMCC respondents did. Their differences of all questions were statistically significant, and we speculate that this is due to their close proximity to AT facilities and personnel. They also used face-to-face communication more often than other methods. In contrast, GMCCs used telephone communication more often. GMCC personnel handled many different kinds of coordination and dealt with various organizations more than AMCC personnel. This might also have made their coordination more difficult and complex.

Table 7. Summary of AMCC and GMCC Respondents' Ratings on Understanding Each Other and Working Relationship

Questions	Average Rating	
	AMCC	GMCC
Current response times to maintenance requests are adequate. (AF: Section E, Question 1) (Rating 1 for "Strongly Disagree" and Rating 10 for "Strongly Agree")	7.7	5.8
There are clearly defined roles for coordinating with AT. (AF: Section E, Question 2) (Rating 1 for "Strongly Disagree" and Rating 10 for "Strongly Agree")	7.8	6.5
How thoroughly do you understand AT tasks and responsibilities? (AF: Section E, Question 8) (Rating 1 for "Barely" and Rating 10 "Extremely Well")	8.2	6.6
How thoroughly do you think AT personnel understand your roles and responsibilities? (AF: Section E, Question 9) (Rating 1 for "Barely" and Rating 10 "Extremely Well")	6.3	5.2
How successful is current AT/AF coordination? (AF: Section E, Question 10) (Rating 1 for "Not Successful" and Rating 10 for "Extremely Successful")	8.5	7.3

This face-to-face communication method enables AF and AT personnel to receive immediate feedback on their requests. It must have helped them build closer and positive working relationship. Warkentin et al. (1997) reported that if coordination was done electronically or virtually, participants experienced team-building problems and got less satisfaction in the process than when they coordinated face-to-face. This argument bears more significance because AF and AT respondents cited a good working relationship as an important factor for a successful coordination.

4.4.2 ARTCC vs. non-ARTCC in AT

On the AT side, ARTCCs are collocated with AMCCs. We expected similar results. For all of the relevant questions, there was no significant difference between ARTCC and non-ARTCC groups. It is not clear why we did not get similar results on the communication method from the ARTCC and non-ARTCC categorization as we did from the AMCC and GMCC categorization. This less distinct difference between the two groups' data may be due to the fact that the frequency difference between ARTCC and non-ARTCC on the usage of face-to-face communication was not as large as the frequency difference between AMCCs and GMCCs (Figure 17 vs. Figure 10).

5. Recommendations

AF and AT have coordinated successfully. However, our analyses of AF and AT respondents' data revealed that a few important coordination practices can be improved. Accordingly, we present several recommendations in the following. They are not in any particular order.

1. Facilitate mutual understanding between AF and AT. Our data and the previous research on coordination showed that it is important to understand the others' needs and responsibilities for efficient coordination. As some respondents suggested, it would facilitate their mutual understanding and make their coordination more effective if they interact more often by receiving training together and holding joint meetings.
2. Devise measures to improve the information-related obstacles in the current coordination between AF and AT. These were the major obstacles according to AF and AT respondents. Specifically, they cited information quality, finding coordinators, and receiving the relevant information in a timely manner. The FAA needs to examine these separately and reduce the current information-related problems.
3. Make the important, helpful information available to the AF and AT coordinating personnel. Some AF and AT respondents expressed that certain information was not available but could be useful for coordination, such as the real-time traffic flow for AF personnel. Some AT respondents mentioned that the information about equipment of the nearby facilities and AF technicians' travel-time to the maintenance site could be beneficial. When AF and AT personnel coordinate, they usually use face-to-face or telephone communication. Thus, if computers relay some information automatically, the coordinators save time. Some AF respondents also thought that there were too many organizations with which to coordinate. If AF personnel can extract the necessary information using computers easily, they may not need to coordinate with all the organizations with which they currently coordinate. Event Manager software supplies most of the necessary information. The FAA needs to make the information available to both AF and AT.
4. Increase the number of AF specialists who coordinate with AT. Twenty-one AT respondents (14% of the AT respondents) mentioned that low AF and AT coordination staffing was a major obstacle. Improving coordination procedures may also improve this situation.
5. Educate the AF and AT personnel who are not the main designated coordinators but may be called upon to coordinate. Our data showed that in AF, MCC specialists were not the only personnel who coordinated with AT. Following the guidelines of a risk management document may solve this problem to some extent. The FAA might also consider that MCC specialists only accomplish the coordination between AF and AT. This could eliminate any confusion in coordinating.
6. Create a separate, local coordination procedure. The current data and other previous studies suggest that local control and face-to-face communication are effective for coordination. Even if the coordination will be handled by three centralized OCCs as planned by the FAA, it may be beneficial to leave certain coordination at the local level and let the local AF sites handle the coordination between them and AT. This requires the FAA to create a local procedure for certain coordination tasks.
7. Make coordinators' roles and responsibilities clear to AF and AT coordinators. The current roles and responsibilities are not clear to some coordinators. The FAA needs to give them training on this.

8. Standardize the terminology. Some AF and AT respondents mentioned that the technical terminology created problems in communicating. The FAA needs to standardize the technical terms and make them available to AF and AT personnel.
9. AF respondents thought the current AT's response time was not ideal. The FAA could use the response times reported here by AF and AT as a guide and see if AF and AT could improve their respective notice and response time to the other coordinating organization. Less optimal response times for both parties may be due to their misunderstanding the necessary coordination procedure.
10. Initiate a new study to address issues raised by this study. This is a baseline study; therefore we could not answer all of them. For instance, we do not know if empowering is useful for AF and AT coordination. Currently, AF does not empower the other organization often. In the ATM environment, empowering has been effective for coordination between AT providers and users. We need to study this further to determine if empowering will benefit AF and AT coordination.

References

Ahlstrom, V., Koros, A., & Heiney, M. (2000). *Team processes in Airway Facilities operations control centers* (DOT/FAA/CT-TN00/14). Atlantic City International Airport, NJ: FAA William J. Hughes Technical Center.

Beatty, R., Corwin, B., & Wambsganss, M. (1999). Collaborative decision-making: A success story of an airline-FAA partnership. In *Proceedings of the Tenth Aviation Psychology Symposium* (pp. 439-444). Columbus: Ohio State University.

Converse, S. A., Cannon-Bowers, J. A., & Salas, E. (1991). Team member shared mental models: A theory and some methodological issues. In *Proceedings of the Human Factors Society 35th Annual Meeting* (pp. 1417-1421). Santa Monica, CA: Human Factors and Ergonomics Society.

Dillman, D. A. (2000). *Mail and Internet surveys: The tailored design method.* New York: Wiley.

Eurocontrol. (1998). *Potential applications of collaborative planning and decision making final report* (EEC Note No. 19/98, EEC Task R23, EATCHIP Task CSD-4-01). European Organisation for the Safety of Air Navigation.

Eurocontrol Experimental Center. (n.d.). *About CDM.* Retrieved April 6, 2000, from http://www.euro-cdm.org/about.htm

Federal Aviation Administration. (1997a). *Airway Facilities strategic plan.* Washington, DC: Author.

Federal Aviation Administration. (1997b). *ATS concept of operations for the National Airspace System in 2005.* Washington, DC: Author.

Federal Aviation Administration. (1999a). *Airway Facilities operations in the NIM environment.* Washington, DC: Author.

Federal Aviation Administration. (1999b). *FAA Order 6000.15C: General maintenance handbook for Airway Facilities (Draft).* Washington, DC: Author.

Federal Aviation Administration. (1999c). *National Airspace System architecture (Version 4.0).* Washington, DC: Author.

Federal Aviation Administration. (2000a). *Airway Facilities.* Retrieved April 6, 2000, from the FAA website: http://www.faa.gov/ats/af/bottom.cfm

Federal Aviation Administration. (2000b). *MCC information.* Retrieved April 6, 2000, from the FAA website: http://aftechnet.faa.gov/mcc/

Federal Aviation Administration. (2000c). *National operations control center (NOCC).* Retrieved October 22, 2000, from the FAA website: http://www.fly.faa.gov/Information/NOCC/nocc.html

Federal Aviation Administration. (2001a). *FAA Order 7210.3R: Facility operation and administration.* Retrieved October 24, 2001, from the FAA website: http://www.faa.gov/atpubs/FAC/INDEX.htm

Federal Aviation Administration. (2001b). *FAA position description: Supervisory Air Traffic Control Specialist, AT-2152.* Retrieved July 18, 2001, from the FAA website: http://pdlibrary.faa.gov/pdtext.asp?pd_number=3035&pd_type=N

Federal Aviation Administration. (2001c). *FAA position description: Supervisory Air Traffic Control Specialist, AT-2152.* Retrieved July 18, 2001, from the FAA website: http://pdlibrary.faa.gov/pdtext.asp?pd_number=3037&pd_type=N

Klein, M. (2000). *Towards a systematic repository of knowledge about managing collaborative design conflicts* (Cambridge, MA: MIT Doc. No. 210). Retrieved December 21, 2000, from http://ccs.mit.edu/abstracts.html

Lacher, A. R., & Klein, G. L. (1993). *Air carrier operations and collaborative decision-making study* (Document Number: MTR93W0000244). McLean, VA: MITRE Corporation.

Langan-Fox, J., Code, S., & Langfield-Smith, K. (2000). Team mental models: Techniques, methods, and analytic approaches. *Human Factors, 42*, 242-271.

MacDonald, L. (1998). Collaborative decision making in aviation. *Journal of Air Traffic Control, 40(3)*, 12-17.

Malone, T. W., & Crowston, K. (2000). The interdisciplinary study of coordination. *ACM Computing Surveys, 26(1)*, 87-119.

Metron, Incorporated. (2000a). *CDM background.* Retrieved April 6, 2000, from http://www.metsci.com/faa/bg.html

Metron, Incorporated. (2000b). *CDM history.* Retrieved April 6, 2000, from http://www.metsci.com/cdm/whatscdm/history.html

National Research Council. (1997). Chapter 9: Human factors in airway facilities. In Wickens, C. D., Mavor, A. S., & McGee, J. P. (Eds.). *Flight to the future: Human factors in Air Traffic Control.* Washington, DC: National Research Council.

Smith, P. J., McCoy, E., Orasanu, J., Billings, C., Denning, R., Rodvold, M., Gee, T., & Horn, A. V. (1998). *Cooperative problem-solving in the interaction of airline dispatchers with ATCSCC* (Ohio State University). Retrieved April 6, 2000, from http://www.hf.faa.gov/docs/coopprob/1airdisp.htm

SPSS, Incorporated. (2000). SPSS 10.1 [Computer software]. Chicago.

Warkentin, M. E., Sayeed, L., & Hightower, R. (1997). Virtual teams versus face-to-face teams: An exploratory study of a web-based conference system. *Decision Sciences Journal, 28,* 975-996.

Acronyms

AF	Airway Facilities
AMCC	Air Route Traffic Control Center Maintenance Control Center
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
AT	Air Traffic
ATC	Air Traffic Control
ATCS	Air Traffic Control Specialist
ATCT	Air Traffic Control Tower
ATC-TFM	Air Traffic Control-Traffic Flow Management
ATM	Air Traffic Management
CDM	Collaborative Decision Making
FAA	Federal Aviation Administration
FI	Flight Inspection
FICO	Flight Inspection Central Operations
FSS	Flight Service Station
GMCC	General Maintenance Control Center
MCC	Maintenance Control Center
NAS	National Airspace System
NMCC	National Maintenance Control Center
NOCC	National Operations Control Center
NOM	NAS Operations Manager
NOTAM	Notice-To-Airmen
OCC	Operations Control Center
OM	Operations Manager
OS	Operations Supervisor
PASS	Professional Airways Systems Specialists
POC	Point of Contact
SD	Standard Deviation
SME	Subject Matter Expert
SMO	Systems Maintenance Office
TFM	Traffic Flow Management
TRACON	Terminal Radar Approach Control

APPENDIX A

Questionnaire Form for AF Specialists

Survey On Coordination Between Airway Facilities Specialists and Air Traffic Personnel

The Research and Development Human Factors Laboratory at the FAA William J. Hughes Technical Center wants your opinions on coordination between AF and AT. Please respond to the attached survey and send it back to us within two to three weeks.

We are very grateful for your cooperation.

Purpose

This questionnaire is designed to explore how Maintenance Control Center (MCC) Airway Facilities (AF) specialists coordinate with Air Traffic (AT) personnel in scheduling maintenance. There are no right or wrong answers to questions. We are interested in knowing your experience and opinions on this topic.

Confidentiality & Anonymity

Data from your responses including demographic data will be anonymous and confidential. This survey is voluntary. You can end this survey anytime you wish. There will be no consequences.

Risk & Benefits

There is no anticipated risk in participating in this survey. The benefit for you from the results of this study includes a better understanding of coordination between AF specialists and AT personnel. This will help you make the NAS more efficient and safe.

This project is very important for the FAA to understand what tasks MCC AF specialists coordinate with AT personnel and how they coordinate. The FAA will use the research results to facilitate coordination between AF specialists and AT personnel.

Your cooperation is greatly appreciated. If you have any questions, please do not hesitate to contact Dr. Hah at the following address.

Sehchang Hah, Ph.D.
Engineering Research Psychologist
(609) 485-5809
Sehchang.Hah@tc.faa.gov

William J. Hughes Technical Center, ACT-530
Bldg. 28, Research and Development Human Factors Laboratory
FAA William J. Hughes Technical Center
Atlantic City International Airport, NJ 08405

INSTRUCTIONS

You will see five different question formats in the following questionnaire.

1. **Fill in the blank** — For some questions, you need to fill in blanks. The space for an answer is underlined. Please fill in above the underline. If you need more space to answer a question, please use a blank sheet of paper. In that case, please write the question number with your answer so we can link your answer to the question.

2. **Ratings** — For some questions, you need to provide ratings. To answer them, please circle the number of the rating you selected. Ratings range from 1 to 10. Please consider the intervals between these two numbers as equally spaced and select one number that would best represent your rating.

3. **Rankings** — When you are asked to rank items according to their frequency or criticality to the questions, please write 1 for the most frequent or critical item. If two items are nearly equal, use your best judgment and rank them differently. For example, if you are asked to rank the frequency of your transportation modes you use to go to work, you may rank "your own car" as 1 if you drive your own car to work most of the time. If the next most frequent mode you use is taking a bus, write 2 for the "bus." Select N/A for those that do not apply.

4. **Multiple choice** — To answer multiple choice questions, circle all that apply.

5. **Percentages** — There are two types of questions to be answered in percentages. For one type, you select a percentage of either 0, 25, 50, 75, or 100. For the other type, you fill in percentages that should add up to 100.

At the end of this questionaire, there is a consent form. This form is to protect your right as a participant in this study. Please fill out, tear off, and return it to the person who handed you the survey. Please note your name does not appear on the survey. We appreciate your cooperation very much.

DEMOGRAPHIC INFORMATION

Current Facility: _____ (Please circle) AMCC GMCC

Position/task: _____ Years/months_____/_____

Previous MCC experience: _____ years

Other AF experience: _____ years

A. OVERALL COORDINATION

1. **Rank the amount of overall coordination you do with each of the following groups:** *(1= most. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___AT Tower personnel
___AT TRACON personnel
___AT Center personnel
___FSS personnel
___NOCC
___AF personnel at other facilities
___AF field technicians
___Flight inspection personnel (e.g., FICO)
___Military contacts associated with joint use facilities
___Other government agencies (e.g., NOAA, FEMA, NASA)
___Local authorities (including airport, fire, police)
___Telephone companies
___Other (Please specify.)_____

2. **Rank the most critical factors for effective AF/AT coordination.** *(1= most critical. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___Getting to the right AT person
___Communication method
___Workload of AT person (e.g. is he/she busy with other duties)
___Understanding and appreciating the other person's duties and responsibilities
___Personality of AT person
___Using the same terminology
___Established relationship between AF and AT
___Well established coordination proceedures
___AT's understanding of what is wrong with the equipment
___Other (Please specify.)_____

3. **Rank the problems you currently face with coordination.** *(1= most problematic. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___Insufficient or inaccurate information
___Not getting the needed information in sufficient time
___Too many groups to coordinate with
___Unclear with whom to coordinate and when
___Communication method
___Inability to reach the right person
___Unclear roles (of who should communicate with whom or who should be making decisions)
___Other (Please specify.)_____
___None

4. **Rank how often you use the following memory aids to tell you <u>what information</u> to use for coordination purposes.** *(1= most often. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___Checklist
___Electronic form with spaces for the needed information
___Paper form with spaces for the needed information
___Flowcharts
___Rely on training and experience
___Handwritten notes on paper or sticky notes
___Other (Please specify.) _____
___None

5. **Rank how often you use the following memory aids to tell you <u>with whom</u> to coordinate.** *(1= most often. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___Checklist
___Electronic form with spaces for the needed information
___Paper form with spaces for the needed information
___Flowcharts
___Rely on training and experience
___Handwritten notes on paper or sticky notes
___Other (Please specify.) _____
___None

6. **Rank the information you use to prioritize maintenance activities?** *(1= most often. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___Is the scheduled event to do corrective maintenance or routine preventative maintenance
___How long does it take to complete the event
___Are there other events scheduled that this event would impact
___Would staff be available if an alternative time was needed
___Impact on requestor (AF) if the event was not approved at the time requested
___Status of adjacent facilities
___Is it a good time in terms of air traffic
___Expected weather conditions at the time of scheduled event
___Level of airport
___Other (Please specify.) _____

7. **When you coordinate with AT personnel, what percentage of the time do you use the following communication methods?** *(Percentages (%) should add to 100.)*

_____% Face-to-face conversation
_____% Telephone
_____% E-mail
_____% Internet
_____% Fax
_____% Formal briefing or regularly scheduled meeting
_____% Other (Please specify.)_____

8. **What time of day do you coordinate with AT personnel?** *(Percentages (%) should add to 100.)*

_____% Morning (6 AM - just before 12 PM)
_____% Afternoon (12 PM - just before 6 PM)
_____% Evening (6 PM - just before 12 AM)
_____% Late Night (12 AM - just before 6 AM)
_____% No particular time

9. What percentage of time do you provide the following information to AT when requesting release for maintenance? *(Please circle the percentage.)*

a. Requesting organization	0	25	50	75	100
b. What the system's function is within the NAS	0	25	50	75	100
c. The criticality of a system or service	0	25	50	75	100
d. Backup systems available	0	25	50	75	100
e. Other current maintenance activities	0	25	50	75	100
f. Date and time of event being coordinated	0	25	50	75	100
g. Expected duration of event being coordinated	0	25	50	75	100
h. Time needed to return to service in case of emergency	0	25	50	75	100
i. AT facilities impacted	0	25	50	75	100
j. Why maintenance is needed	0	25	50	75	100
k. Consequences if maintenance doesn't occur (e.g., if the window for maintenance is closed)	0	25	50	75	100
l. Procedures for AT to contact AF if immediate restoration should be necessary	0	25	50	75	100
m. Resources currently being applied to resolve the problem	0	25	50	75	100
n. Additional resources needed to perform the maintenance	0	25	50	75	100
o. Other scheduled events that this event would impact	0	25	50	75	100
p. Status of adjacent facilities	0	25	50	75	100
q. Other (Please specify.)_____	0	25	50	75	100

10. What percentage of time does AT provide the following information to you when you are coordinating maintenance activities? *(Please circle the percentage.)*

a. Current and expected traffic conditions	0	25	50	75	100
b. Current and expected weather conditions	0	25	50	75	100
c. Chances for approval at the requested time	0	25	50	75	100
d. Alternate time or times available	0	25	50	75	100
e. Backup systems required	0	25	50	75	100
f. Special events (e.g., VIP flights, shuttle launch, air show)	0	25	50	75	100
g. Other (Please specify.)_____	0	25	50	75	100

11. Is there additional information from AT that is <u>NOT</u> currently provided to you that would benefit coordination? *(Circle all that apply.)*

a. Real time depiction of aircraft flow
b. Real time depiction of weather
c. Backup systems required
d. Special events (e.g., VIP flights, space shuttle launch, air show)
e. Other (Please specify.)_____
f. None

12. Is there additional information that is <u>NOT</u> currently provided to AT that would benefit coordination? *(Circle all that apply.)*

a. Maintainer schedules
b. Interdependencies of systems
c. Status of equipment at nearby facilities
d. Availability of parts
e. Travel time for technicians
f. Other (Please specify.) _____
g. None

B SCHEDULED EVENT COORDINATION

1. **When performing the final assessment for release for Scheduled Events, what information do you collect from AT personnel?** *(Circle all that apply.)*

   a. Is the previously approved schedule still good?
   b. If the approved schedule is not good, is there an alternate time available?
   c. Has AT made the necessary arrangement to use any available backup systems?
   d. Other (Please specify.)_____

2. **What Scheduled Event interactions with AT are currently recorded?** *(Circle all that apply.)*

   a. All exchanges between the organizations
   b. Initial contact between AT and AF
   c. Contact with AT resulting in new information
   d. Updates to AT by AF
   e. Other (Please specify.)_____

3. **On average, how much in advance do you usually inform AT personnel of a Scheduled Event for short-term (less than 5 hours to complete) maintenance?**

   _____ days _____ hours _____ minutes

4. **On average, how much in advance do you usually inform AT personnel of a Scheduled Event for long-term (5 or more hours to complete) maintenance?**

   _____ days _____ hours _____ minutes

5. **On average, how soon do you usually receive either approval or disapproval responses from AT for a short-term (less than 5 hours to complete) Scheduled Event?**

   _____ days _____ hours _____ minutes

6. **On average, how soon do you usually receive either approval or disapproval responses from AT for a long-term (5 or more hours to complete) Scheduled Event?**

   _____ days _____ hours _____ minutes

7. **What percentage of the time does AT ask to reschedule a Scheduled Event?**_____ %

C UNSCHEDULED EVENT COORDINATION

1. What percentage of time do you provide the following information to AT as you coordinate Unscheduled Events? *(Please circle the percentage.)*

a. Expected restoration time	0	25	50	75	100
b. Are there other events scheduled that this event would impact? (e.g., Scheduled Events that may need to be cancelled)	0	25	50	75	100
c. Status of adjacent facilities	0	25	50	75	100
d. When are the other facilities expected to be returned to service (RTS)	0	25	50	75	100
e. Activities needed to restore	0	25	50	75	100
f. Availability of staff if an alternate time is needed	0	25	50	75	100
g. Frequency of status updates	0	25	50	75	100
h. Equipment and services affected	0	25	50	75	100
i. Cause of event	0	25	50	75	100
j. Availability of technicians with necessary skills	0	25	50	75	100
k. Status of technicians (e.g., on site, en route, expected arrival time)	0	25	50	75	100
l. Status of needed parts (e.g., availability)	0	25	50	75	100
m. Other (Please specify.)_____	0	25	50	75	100

2. What percentage of time does AT provide the following information to you as you coordinate Unscheduled Events? *(Please circle the percentage.)*

a. Potential impact on NAS operations	0	25	50	75	100
b. Potential traffic delays	0	25	50	75	100
c. Restoration time requirements	0	25	50	75	100
d. Relative importance to the flow of traffic at other facilities	0	25	50	75	100
e. Current and expected weather conditions	0	25	50	75	100
f. Backup systems or procedures in use during the time of the event	0	25	50	75	100
g. Special conditions that may be impacted (e.g., VIP flight)	0	25	50	75	100
h. How well the transition to backup proceeded	0	25	50	75	100
i. Air traffic restrictions implemented	0	25	50	75	100
j. Other (Please specify.)_____	0	25	50	75	100

3. What Unscheduled Event interactions with AT are currently recorded? *(Circle all that apply.)*

a. All exchanges between the organizations
b. Initial contact between AT and AF
c. Contact with AT resulting in new information
d. Updates to AT by AF
e. Other (Please specify.) _____

4. How soon do you usually receive responses from AT, either approval or disapproval, for an Unscheduled Event?

_____ days _____ hours _____ minutes

D FLIGHT INSPECTION (FI) COORDINATION

1. What percentage of time do you provide the following information to AT as you coordinate Flight Inspections? *(Please circle the percentage.)*

a. The facility being inspected	0	25	50	75	100
b. The time requested by AF and FI personnel	0	25	50	75	100
c. The identifier	0	25	50	75	100
d. Runway number (if ILS system)	0	25	50	75	100
e. Estimated length of the inspection	0	25	50	75	100
f. The type of inspection (e.g., routine, post accident, or a commissioning FI)	0	25	50	75	100
g. Whether AT person needs to be designated for entire FI	0	25	50	75	100
h. Preferred alternative schedule if required	0	25	50	75	100
i. Consequences of not being able to complete the FI	0	25	50	75	100
j. FI aircraft tail number	0	25	50	75	100
k. Pattern of flight in airspace . (e.g. circling in a particular area, landing, etc.)	0	25	50	75	100
l. Other (Please specify.)_____	0	25	50	75	100

2. What percentage of time does AT provide the following information to you as you coordinate Flight Inspections? *(Please circle the percentage.)*

a. Expected traffic conditions at time of scheduled FI	0	25	50	75	100
b. Effect on traffic flow	0	25	50	75	100
c. Availability of AT personnel to help FI if needed	0	25	50	75	100
d. Are interruptions to the FI possible (e.g. due to traffic)	0	25	50	75	100
e. Other (Please specify.)_____	0	25	50	75	100

3. With whom do you coordinate when closing out a flight inspection event (e.g., if a NOTAM is issued or cancelled)? *(Circle all that apply.)*

a. AT Tower personnel
b. AT TRACON personnel
c. AT Center personnel
d. FSS personnel
e. NOCC
f. AF personnel at other facilities
g. AF field technicians
h. Flight inspection personnel
i. Military contacts associated with joint use facilities
j. Other (Please specify.)_____
k. None

E. YOUR OPINION

1. **Current response times to maintenance requests are adequate.** *(Please circle.)*

Strongly Disagree 1 2 3 4 5 6 7 8 9 10 Strongly Agree

2. **There are clearly defined roles for coordinating with AT.** *(Please circle.)*

Strongly Disagree 1 2 3 4 5 6 7 8 9 10 Strongly Agree

3. **There are mechanisms in place to detect inappropriate decisions (to accept/deny maintenance).** *(Please circle.)*

Strongly Disagree 1 2 3 4 5 6 7 8 9 10 Strongly Agree

4. **What are the most successful aspects of current AF/AT coordination?**

---

5. **Please describe any obstacles you currently face with coordination.**

---

6. **Please describe any suggestions you have for improving the current coordination process with AT.**

---

7. **How often do AT personnel prioritize your maintenance tasks for you?**

Never 1 2 3 4 5 6 7 8 9 10 Always

8. **How thoroughly do you understand AT tasks and responsibilities?**

Barely 1 2 3 4 5 6 7 8 9 10 Extremely Well

9. **How thoroughly do you think AT personnel understand your roles and responsibilities?**

Barely 1 2 3 4 5 6 7 8 9 10 Extremely Well

10. **How successful is current AT/AF coordination?**

Not successful 1 2 3 4 5 6 7 8 9 10 Extremely successful

CONSENT FORM

Please fill out, tear off, and return it to the person who handed you the survey.

FAA William J. Hughes Technical Center
Research and Development Human Factors Laboratory

Individual's Consent to Voluntary Participation in a Research Project

I, _____, understand that this project, entitled "Coordination Between Airway Facilities Specialists and Air Traffic Personnel," is sponsored by the Federal Aviation Administration and is being directed by Research and Development Human Factors Laboratory.

Nature and Purpose: I volunteer to participate in the project titled above as a participant. I know that the purpose of the project is to study how Airway Facilities specialists coordinate with Air Traffic personnel in scheduling maintenance.

Experimental Procedures: I will complete a questionnaire. I know that the records of this study are strictly confidential, and I will not be identifiable by name or description in any reports or publications. I understand that all collected information is for use within the Research and Development Human Factors Laboratory only.

Discomfort and Risks: My role in this study is to complete a questionnaire. I do not foresee any harmful effects on me by participating. However, if I choose, I can stop participation at anytime without any consequences.

Precautions for Female Participants (if any): There are no special precautions required.

Benefits: I receive no special benefits from my participation. However, the results may lead to a better understanding of coordination between Airway Facilities specialists and Air Traffic personnel.

Participant Responsibilities: I will complete a questionnaire that will take about an hour.

Compensation and Injury: (Although this is a survey study, the following is included in all informed consent documents.) I agree to immediately report any injury or suspected adverse effect to my supervisor. I understand that accident insurance coverage for this activity is provided by my own insurance and that necessary immediate care of resultant medical problems may be provided by my facility until, or unless, transportation to another medical facility is obtained. Local clinics and hospitals would provide follow-on care. I agree to provide, if requested, copies of all insurance and medical records arising from any such care for injuries/medical problems.

Participant's Assurances: I understand that my participation in this study is completely voluntary. I am participating because I want to. Dr. Sehchang Hah has adequately answered any and all questions I have about this study, my participation, and the procedures involved. I understand that Dr. Sehchang Hah will be available to answer any additional questions concerning procedures throughout this study.

I understand that if new findings develop during the course of this research that may relate to my decision to continue participation, I will be informed. I have not given up any of my legal rights or released any individual or institution from liability for negligence. I understand that records of this study will be kept confidential, and that I will not be identifiable by name or description in any reports or publications about this study. I understand that I may withdraw from this study at any time without penalty or loss of benefits to which I am otherwise entitled. I also understand that the researcher or medical monitor of this study may terminate my participation if he/she feels this to be in my best interest. If I have questions about this study or need to report any adverse effects from the research procedures, I will contact Dr. Sehchang Hah at (609)-485-5809.

Signature Lines:
I have read this consent document. I understand its contents, and I freely consent to participate in this study under the conditions described. I may make a copy of this consent form if I wish.

Research Participant: _____ Date:_____

Investigator: _____ Date:_____

APPENDIX B

Questionnaire Form for AT Personnel

AIR TRAFFIC

Purpose

This questionnaire is designed to explore how Air Traffic (AT) personnel coordinate with Maintenance Control Center (MCC) Airway Facilities (AF) specialists in scheduling maintenance. There are no right or wrong answers to questions. We are interested in knowing your experience and opinions on this topic.

Confidentiality & Anonymity

Data from your responses including demographic data will be anonymous and confidential. This survey is voluntary. You can end this survey anytime you wish. There will be no consequences.

Risk & Benefits

There is no anticipated risk in participating in this survey. The benefit for you from the results of this study includes a better understanding of coordination between AT personnel and AF specialists. This will help you make the NAS more efficient and safe.

This project is very important for the FAA to understand what tasks AT personnel coordinate with MCC AF specialists and how they coordinate. The FAA will use the research results to facilitate coordination between AT personel and AF specialists.

Your cooperation is greatly appreciated. If you have any questions, please do not hesitate to contact Dr. Hah at the following address.

Sehchang Hah, Ph.D.
Engineering Research Psychologist
(609) 485-5809
Sehchang.Hah@tc.faa.gov

William J. Hughes Technical Center, ACT-530
Bldg. 28, Research and Development Human Factors Laboratory
FAA William J. Hughes Technical Center
Atlantic City International Airport, NJ 08405

INSTRUCTIONS

You will see five different question formats in the following questionnaire.

1. **Fill in the blank** — For some questions, you need to fill in blanks. The space for an answer is underlined. Please fill in above the underline. If you need more space to answer a question, please use a blank sheet of paper. In that case, please write the question number with your answer so we can link your answer to the question.

2. **Ratings** — For some questions, you need to provide ratings. To answer them, please circle the number of the rating you selected. Ratings range from 1 to 10. Please consider the intervals between these two numbers as equally spaced and select one number that would best represent your rating.

3. **Rankings** — When you are asked to rank items according to their frequency or criticality to the questions, please write 1 for the most frequent or critical item. If two items are nearly equal, use your best judgment and rank them differently. For example, if you are asked to rank the frequency of your transportation modes you use to go to work, you may rank "your own car" as 1 if you drive your own car to work most of the time. If the next most frequent mode you use is taking a bus, write 2 for the "bus." Select N/A for those that do not apply.

4. **Multiple choice** — To answer multiple choice questions, circle all that apply.

5. **Percentages** — There are two types of questions to be answered in percentages. For one type, you select a percentage of either 0, 25, 50, 75, or 100. For the other type, you fill in percentages that should add up to 100.

At the end of this questionaire, there is a consent form. This form is to protect your right as a participant in this study. Please fill out, tear off, and return it to the person who handed you the survey. Please note your name does not appear on the survey. We appreciate your cooperation very much.

DEMOGRAPHIC INFORMATION

Current Facility: _____

Position/task: _____

How many years of experience do you have working this position? _____

A OVERALL COORDINATION

1. **Rank the most critical factors for effective AT/AF coordination.** *(1= most critical. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___Getting to the right AF person
___Communication method
___Workload of AF person (e.g. is he/she busy with other duties)
___Understanding and appreciating the other person's duties and responsibilities
___Personality of AF person
___Using the same terminology
___Established relationship between AT and AF
___Well established coordination procedures
___AT's understanding of what is wrong with the equipment
___Other (Please specify.)_____

2. **Rank the problems you currently face with coordination.** *(1= most problematic. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___Insufficient or inaccurate information
___Not getting information that you need in sufficient time
___Too many groups to coordinate with
___Unlclear with whom to coordinate and when
___Communication method
___Inability to reach the right person
___Unclear roles (of who should communicate with whom or who should be making decisions)
___Other (Please specify.)_____
___None

3. **Rank how often you use the following memory aids to tell you <u>what information</u> to use for coordination purposes.** *(1= most often. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___Checklist
___Electronic form with spaces for the needed information
___Paper form with spaces for the needed information
___Flowcharts
___Rely on training and experience
___Handwritten notes on paper or sticky notes
___Other (Please specify.)_____
___None

4. **Rank how often you use the following memory aids to tell you <u>with whom</u> to coordinate.** *(1= most often. Put N/A for choices that don't apply. If two items are nearly equal, please use your best judgment and rank them differently.)*

___Checklist
___Electronic form with spaces for the needed information
___Paper form with spaces for the needed information
___Flowcharts
___Rely on training and experience
___Handwritten notes on paper or sticky notes
___Other (Please specify.)_____
___None

5. **When you coordinate with AF personnel, what percentage of the time do you use the following communication methods?** *(Percentages (%) should add to 100.)*

_____% Face-to-face conversation
_____% Telephone
_____% E-mail
_____% Internet
_____% Fax
_____% Formal briefing or regularly scheduled meeting
_____% Other (Please specify.)_____

6. **What time of day do you coordinate with AF personnel?** (Percentages (%) should add to 100.)

_____% Morning (6 AM - just before 12 PM)
_____% Afternoon (12 PM - just before 6 PM)
_____% Evening (6 PM - just before 12 AM)
_____% Late Night (12 AM - just before 6 AM)
_____% No particular time

7. **What percentage of time do you provide the following information to AF when they are coordinating maintenance activities?** *(Please circle the percentage.)*

a. Current and expected traffic conditions	0	25	50	75	100
b. Current and expected weather conditions	0	25	50	75	100
c. Chances for approval at the requested time	0	25	50	75	100
d. Alternate time or times available	0	25	50	75	100
e. Backup systems required	0	25	50	75	100
f. Special events (e.g., VIP flights, shuttle launch, air show)	0	25	50	75	100
g. Other (Please specify.)_____	0	25	50	75	100

8. **What percentage of time does AF provide the following information to you when they are coordinating maintenance activities?** *(Please circle the percentage.)*

a. Requesting organization	0	25	50	75	100
b. What the system's function is within the NAS	0	25	50	75	100
c. The criticality of a system or service	0	25	50	75	100
d. Backup systems available	0	25	50	75	100
e. Other current maintenance activities	0	25	50	75	100
f. Date and time of event being coordinated	0	25	50	75	100
g. Expected duration of event being coordinated	0	25	50	75	100
h. Time needed to return to service in case of emergency	0	25	50	75	100
i. AT facilities impacted	0	25	50	75	100
j. Why maintenance is needed	0	25	50	75	100
k. Consequences if maintenance doesn't occur (e.g., if the window for maintenance is closed)	0	25	50	75	100
l. Procedures for AT to contact AF if immediate restoration should be necessary	0	25	50	75	100
m. Resources currently being applied to resolve the problem	0	25	50	75	100
n. Additional resources needed to perform the maintenance	0	25	50	75	100
o. Other scheduled events that this event would impact	0	25	50	75	100
p. Status of adjacent facilities	0	25	50	75	100
q. Other (Please specify.)_____	0	25	50	75	100

9. **Is there additional information from AF that is <u>NOT</u> currently provided to you that would benefit coordination?** *(Circle all that apply.)*

a. Maintainer schedules
b. Interdependencies of systems
c. Status of equipment at nearby facilities
d. Availability of parts
e. Travel time for technicians
f. Other (Please specify.) _____
g. None

B SCHEDULED EVENT (Routine Maintenance Including Equipment Shutdown) COORDINATION

1. **Just before releasing something for scheduled maintenance, what information does AF ask from you?** *(Please circle all that apply.)*

   a. Is the previously approved schedule still good?
   b. If the approved schedule is not good, is there an alternate time available?
   c. Has AT made the necessary arrangement to use any available backup systems?
   d. Other (Please specify.)_____

2. **What Scheduled Event coordination interactions with AF do you record?** *(Circle all that apply.)*

   a. All exchanges between the organizations
   b. Initial contact between AT and AF
   c. Contact with AF resulting in new information
   d. Updates to AT by AF
   e. Other (Please specify.)_____

3. **On average, how much lead time do you usually get from AF for a short-term (less than 5 hours to complete) Scheduled Event?**

   _____ days _____ hours _____ minutes

4. **On average, how much lead time do you usually get from AF for a long-term (5 or more hours to complete) Scheduled Event?**

   _____ days _____ hours _____ minutes

5. **How soon do you usually give either approval or disapproval responses back to AF for a short-term (less than 5 hours to complete) Scheduled Event?**

   _____ days _____ hours _____ minutes

6. **How soon do you usually give either approval or disapproval responses back to AF for a long-term (5 or more hours to complete) Scheduled Event?**

   _____ days _____ hours _____ minutes

C OUTAGE (Equipment Failure Or Improper Operation) COORDINATION

1. What percentage of time does AF provide the following information to you when they are coordinating restoration of an outage? *(Please circle the percentage.)*

a. Expected restoration time	0	25	50	75	100
b. Are there other events scheduled that this event would impact? (e.g., Scheduled Events that may need to be cancelled)	0	25	50	75	100
c. Status of adjacent facilities	0	25	50	75	100
d. When are the other facilities expected to be returned to service (RTS)	0	25	50	75	100
e. Activities needed to restore	0	25	50	75	100
f. Availability of staff if an alternate time is needed	0	25	50	75	100
g. Frequency of status updates	0	25	50	75	100
h. Equipment and services affected	0	25	50	75	100
i. Cause of event	0	25	50	75	100
j. Availability of technicians with necessary skills	0	25	50	75	100
k. Status of technicians (e.g., on site, en route, expected arrival time)	0	25	50	75	100
l. Status of needed parts (e.g., availability)	0	25	50	75	100
m. Other (Please specify.)_____	0	25	50	75	100

2. What percentage of time do you provide the following information to AF when they are coordinating restoration of an outage? *(Please circle the percentage.)*

a. Potential impact on NAS operations	0	25	50	75	100
b. Potential traffic delays	0	25	50	75	100
c. Restoration time requirements	0	25	50	75	100
d. Relative importance to the flow of traffic at other facilities	0	25	50	75	100
e. Current and expected weather conditions	0	25	50	75	100
f. Backup systems or procedures in use during the time of the event	0	25	50	75	100
g. Special conditions that may be impacted (e.g., VIP flight)	0	25	50	75	100
h. How well the transition to backup proceeded	0	25	50	75	100
i. Air traffic restrictions implemented	0	25	50	75	100
j. Other (Please specify.)_____	0	25	50	75	100

3. What parts of outage coordination with AF are currently recorded? *(Circle all that apply.)*

a. All exchanges between the organizations
b. Initial contact between AT and AF
c. Contact with AF resulting in new information
d. Updates to AT by AF
e. Other (Please specify.)_____

D FLIGHT INSPECTION (FI) COORDINATION

1. **What percentage of time does AF provide the following information to you as they coordinate Flight Inspections?** *(Please circle the percentage.)*

a. The facility being inspected	0	25	50	75	100
b. The time requested by AF and FI personnel	0	25	50	75	100
c. The identifier	0	25	50	75	100
d. Runway number (if ILS system)	0	25	50	75	100
e. Estimated length of the inspection	0	25	50	75	100
f. The type of inspection (e.g., routine, post accident, or a commissioning FI)	0	25	50	75	100
g. Whether AT person needs to be designated for entire FI	0	25	50	75	100
h. Preferred alternative schedule if required	0	25	50	75	100
i. Consequences of not being able to complete the FI	0	25	50	75	100
j. FI aircraft tail number	0	25	50	75	100
k. Pattern of flight in airspace . (e.g. circling in a particular area, landing, etc.)	0	25	50	75	100
l. Other (Please specify.)_____	0	25	50	75	100

2. **What percentage of time do you provide the following information to AF as they coordinate Flight Inspections?** *(Please circle the percentage.)*

a. Expected traffic conditions at time of scheduled FI	0	25	50	75	100
b. Effect on traffic flow	0	25	50	75	100
c. Availability of AT personnel to help FI if needed	0	25	50	75	100
d. Are interruptions to the FI possible (e.g. due to traffic)	0	25	50	75	100
e. Other (Please specify.)_____	0	25	50	75	100

E YOUR OPINION

1. **There are clearly defined roles for coordinating with AF.** *(Please circle.)*

Strongly Disagree — Strongly Agree

1 2 3 4 5 6 7 8 9 10

2. **What are the most successful aspects of current AF/AT coordination?**

_____

_____

_____

3. **Please describe any obstacles you currently face with coordination.**

_____

_____

_____

4. **Please describe any suggestions you have for improving the current coordination process with AF.**

_____

_____

_____

5. **How thoroughly do you understand AF tasks and responsibilities?**

Barely — Extremely Well

1 2 3 4 5 6 7 8 9 10

6. **How thoroughly do you think AF specialists understand your roles and responsibilities?**

Barely — Extremely Well

1 2 3 4 5 6 7 8 9 10

7. **How successful is current AT/AF coordination?**

Not successful — Extremely successful

1 2 3 4 5 6 7 8 9 10

CONSENT FORM

Please fill out, tear off, and return it to the person who handed you the survey.

FAA William J. Hughes Technical Center
Research and Development Human Factors Laboratory

Individual's Consent to Voluntary Participation in a Research Project

I, _____, understand that this project, entitled "Coordination Between Airway Facilities Specialists and Air Traffic Personnel," is sponsored by the Federal Aviation Administration and is being directed by Research and Development Human Factors Laboratory.

Nature and Purpose: I volunteer to participate in the project titled above as a participant. I know that the purpose of the project is to study how Airway Facilities specialists coordinate with Air Traffic personnel in scheduling maintenance.

Experimental Procedures: I will complete a questionnaire. I know that the records of this study are strictly confidential, and I will not be identifiable by name or description in any reports or publications. I understand that all collected information is for use within the Research and Development Human Factors Laboratory only.

Discomfort and Risks: My role in this study is to complete a questionnaire. I do not foresee any harmful effects on me by participating. However, if I choose, I can stop participation at anytime without any consequences.

Precautions for Female Participants (if any): There are no special precautions required.

Benefits: I receive no special benefits from my participation. However, the results may lead to a better understanding of coordination between Airway Facilities specialists and Air Traffic personnel.

Participant Responsibilities: I will complete a questionnaire that will take about an hour.

Compensation and Injury: (Although this is a survey study, the following is included in all informed consent documents.) I agree to immediately report any injury or suspected adverse effect to my supervisor. I understand that accident insurance coverage for this activity is provided by my own insurance and that necessary immediate care of resultant medical problems may be provided by my facility until, or unless, transportation to another medical facility is obtained. Local clinics and hospitals would provide follow-on care. I agree to provide, if requested, copies of all insurance and medical records arising from any such care for injuries/medical problems.

Participant's Assurances: I understand that my participation in this study is completely voluntary. I am participating because I want to. Dr. Sehchang Hah has adequately answered any and all questions I have about this study, my participation, and the procedures involved. I understand that Dr. Sehchang Hah will be available to answer any additional questions concerning procedures throughout this study.

I understand that if new findings develop during the course of this research that may relate to my decision to continue participation, I will be informed. I have not given up any of my legal rights or released any individual or institution from liability for negligence. I understand that records of this study will be kept confidential, and that I will not be identifiable by name or description in any reports or publications about this study. I understand that I may withdraw from this study at any time without penalty or loss of benefits to which I am otherwise entitled. I also understand that the researcher or medical monitor of this study may terminate my participation if he/she feels this to be in my best interest. If I have questions about this study or need to report any adverse effects from the research procedures, I will contact Dr. Sehchang Hah at (609)-485-5809.

Signature Lines:
I have read this consent document. I understand its contents, and I freely consent to participate in this study under the conditions described. I may make a copy of this consent form if I wish.

Research Participant: _____ Date:_____

Investigator: _____ Date:_____

APPENDIX C

AF Results

AF Results

In the following we summarized the data of all of the questions except the demographic data, which were already summarized in the main body of this report (see the Appendices A for the full descriptions of AF questionnaires). In the following graphs, the numbers in the parentheses by the legend items are the number of valid responses, i.e., the total number of participants who responded to that particular item. Usually the number of participants who responded to "Other" was small. Because of that, we did not mention the data for this "Other" item unless there were any significant facts to report. The number of respondents for each question varied because not all of them answered all of the questions.

For some questions, we examined the distributions of the AF personnel responses based on their work experience to examine the effect of experience on types of information they relayed to the AT (Section A: Question 9 and Section C, Question 1) and MCC types (i.e., AMCC and GMCC) on various issues as mentioned in the main body of this report (Questions 1, 2, and 3 in Section A; Questions 1, 2, 3, 7, 8, 9, and 10 in Section E).

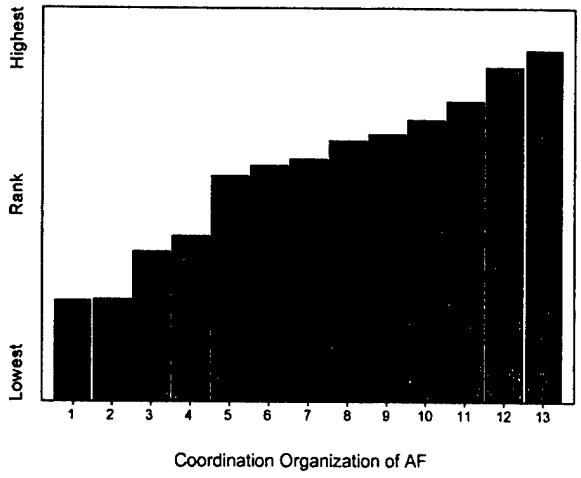
All tests were done without including the data of the "Other" items because not many responded to that item. For Questions 1, 2, and 3 in Section A and Question 1 of Section C were tested using Mann-Whitney U test. This non-parametric test combines data of the two groups, rank them, and test if the ranks of one group are higher than those of the other group. Because the values of respondents' answers to questions in Section E were single rating values, we could use parametric independent *t* tests for them.

In the following graphs for rank data, even though respondents used smaller numbers to designate higher ranks (such as 1 as the highest), we showed high ranks as high bars in the graphic representation. For this purpose, we subtracted the raw ranks from the total number of items in the question and used these new numbers for graphic representation. We ordered the items by rank on the x-axis.

A. Overall Coordination

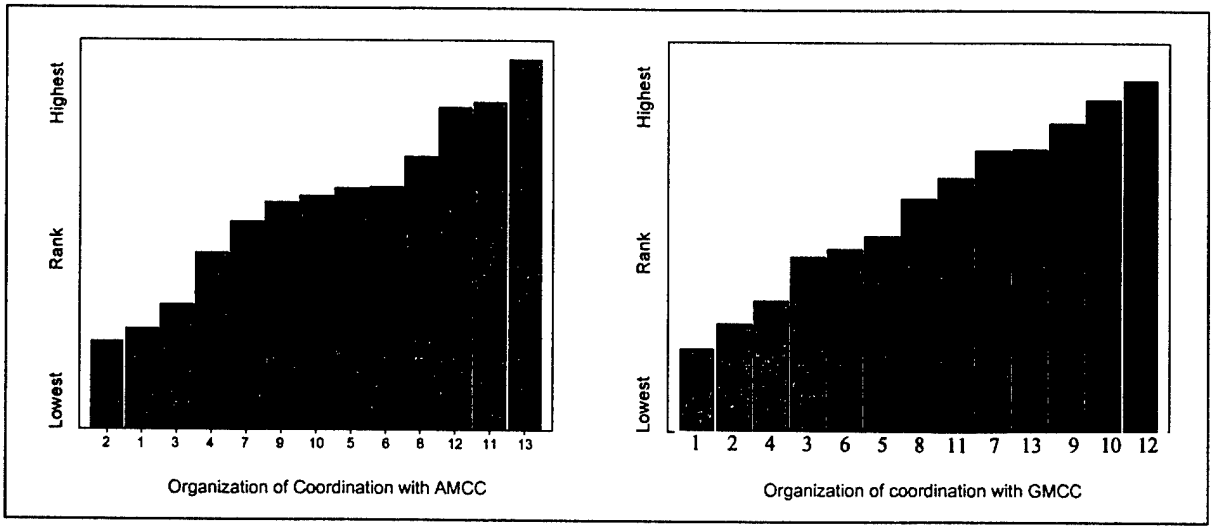
1. Rank the amount of overall coordination you do with each of the following groups.

The most frequent contacts were made to AT Center personnel (Item 13). The next frequent-contacts were made to AF field technicians (Item 12) and AF personnel in other facilities (Item 11). The general pattern of the data shows that most of the contacts were made to either AT (Items 9, 10, and 11) or AF personnel (Items 5, 7, 11, and 12). The contacts to telephone companies were also frequent (Item 8).



1: Other government agencies (e.g., NOAA, FEMA, NASA) (69)
2: Local authorities (including airport, fire, police) (74)
3: FI personnel (e.g., FI Central Operations [FICO]) (67)
4: Military contacts associated with joint use facilities (75)
5: NOCC (83)
6: Other (Please specify.) (12)
7: FSS personnel (81)
8: Telephone companies (87)
9: AT Tower personnel (78)
10: AT TRACON personnel (78)
11: AF personnel at other facilities (86)
12: AF field technicians (86)
13: AT Center personnel (78)

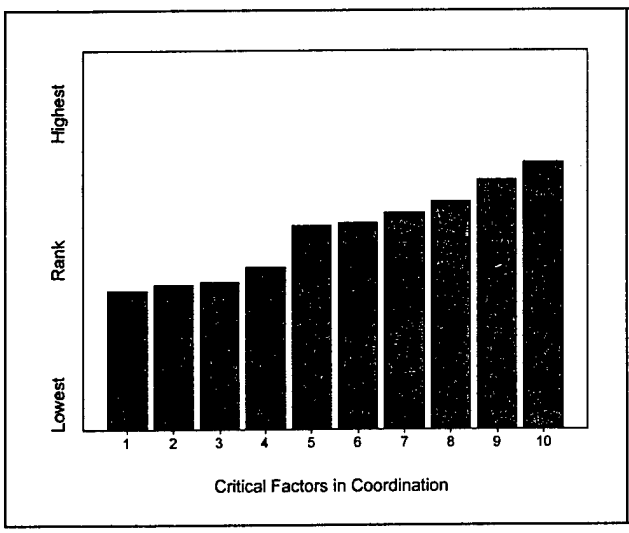
AMCC AF personnel coordinated with AT Center personnel (Item 13) most often. This may be because their work locations were at the same facility. They coordinated with AF personnel at other facilities (Item 11) and technicians (Item 12) frequently. GMCC personnel coordinated with field technicians (Item 12) most frequently. They also coordinated with AT TRACON (Item 10), AT Tower (Item 9), and FSS personnel (Item 7) more often than AMCC personnel did with them. All items except Items 2 ($p = 0.439$) and 6 ($p = 0.197$) were significantly different between AMCC and GMCC (Mann-Whitney U test).



2. Rank the critical factors for effective AF/AT coordination.

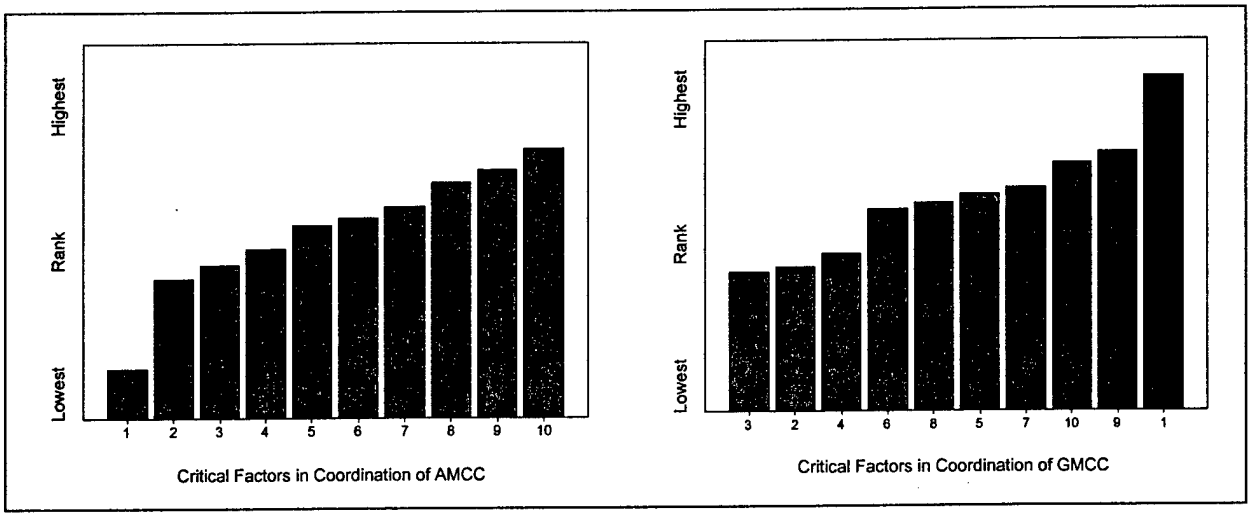
The highest ranked critical factor was the "Established relationship between AF and AT (Item 10)." This is followed by the "Well established coordination procedure (Item 9)." Other highly ranked items were "Communication method (Item 8)," "Understanding and appreciating the other person's duties and responsibilities (Item 7)," "Getting to the right person (Item 6)," and

"Using the same terminology (Item 5)." Except the seventh item, i.e., "Understanding and appreciating the other person's duties and responsibilities (Item 7)," all the others were about the first contact they make to coordinate.



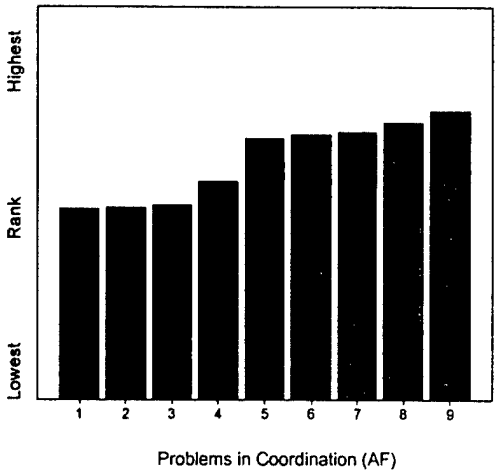
1. Other (Please specify.) (6)
2. Personality of AT person (78)
3. Workload of AT person (e.g. is he/she busy with other duties) (85)
4. AT's understanding of what is wrong with the equipment (84)
5. Using the same terminology (89)
6. Getting to the right AT person (85)
7. Understanding and appreciating the other person's duties and responsibilities (89)
8. Communication method (83)
9. Well established coordination procedures (88)
10. Established relationship between AF and AT (91)

There was no significant difference in selecting critical factors between the two MCC groups (Mann-Whitney U test; $p > .05$).



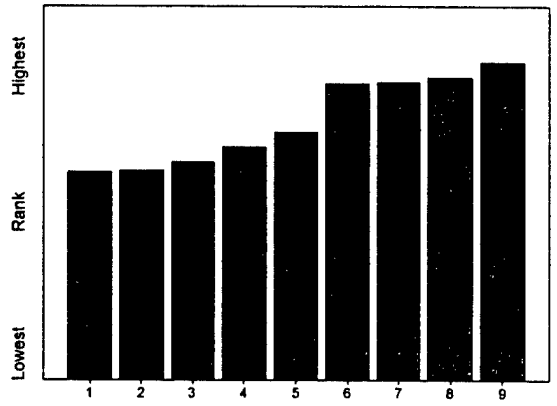
3. Rank the problems you currently face with coordination.

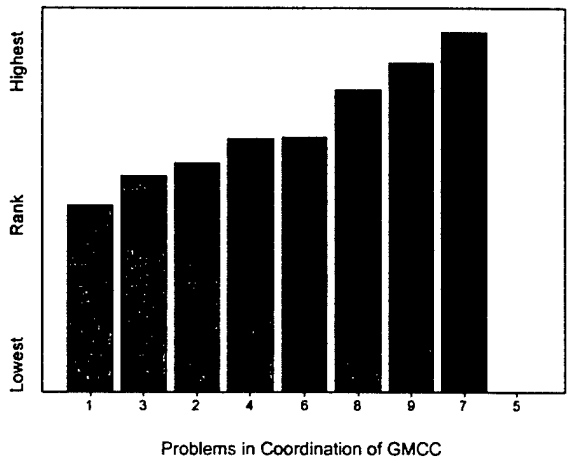
The results show that the major problem is related to information: what information (Item 9) and getting it in a timely manner (Item 8). Respondents also indicated that there were too many groups to coordinate with (Item 6).



1. Communication method (66)
2. Unclear roles (of who should communicate with whom or who should be making decisions) (56)
3. Unclear with whom to coordinate and when (57)
4. Inability to reach the right person (64)
5. None (4)
6. Too many groups to coordinate with (70)
7. Other (Please specify.) (8)
8. Not getting the need information in sufficient time (77)
9. Insufficient or inaccurate information (77)

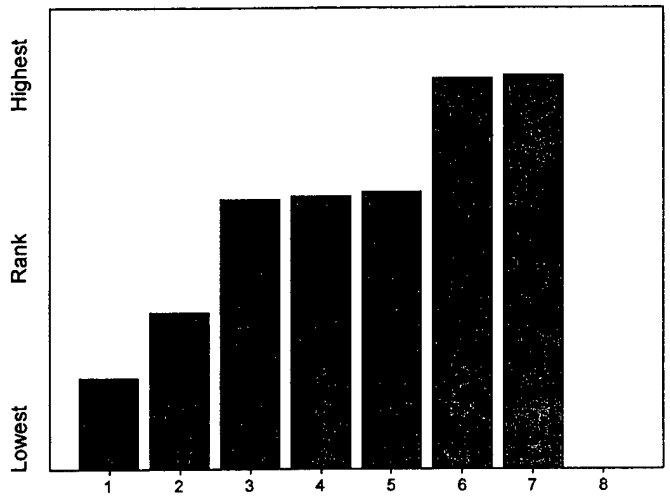
Comparatively, more GMCC personnel than AMCC personnel perceived there were too many to coordinate with (Item 6) (Mann-Whitney U test, $p < .05$). Other items were not significantly different between these two groups.





4. Rank how often you use the following memory aids to tell you <u>what information</u> to use for coordination purposes.

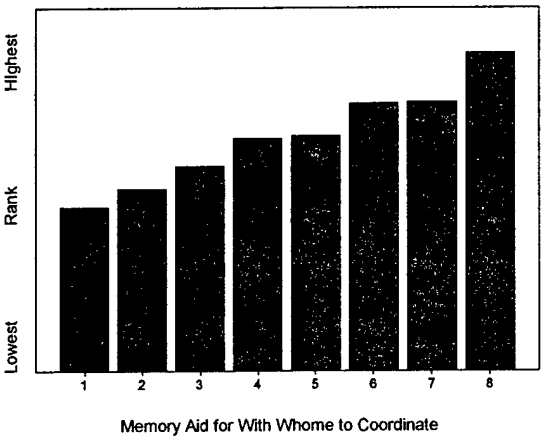
The results showed that they used Event Manager or other computer software (Item 6) and their past training and experience (Item 7) as memory aids of information most frequently. They used electronic form (Item 6) more often than paper forms (Items 1, 3, 4, and 5).



1. Flowcharts (47)
2. Other (Please specify.) (7)
3. Handwritten notes on paper or sticky notes (74)
4. Checklist (69)
5. Paper form with spaces for the needed information (56)
6. Electronic form with spaces for the needed information (70)
7. Rely on training and experience (90)
8. None (0)

5. Rank how often you use the following memory aids to tell you <u>with whom</u> to coordinate.

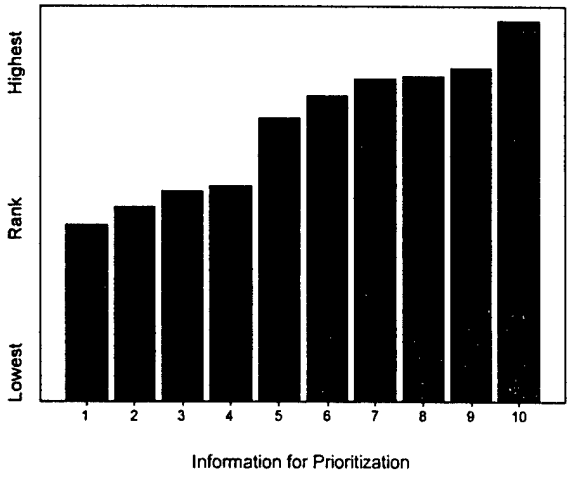
The respondents' responses were similar to theirs to Question 4 about the information memory-aids. Again, their most frequent memory aid to record with whom to coordinate were electronic form (Item 6) and previous training and experience (Item 7). They also used electronic form (Item 6) more often than paper forms (Items 1, 3, 4, and 5).



1. Flowcharts (43)
2. Other (5) (Please specify.)
3. Handwritten notes on paper or sticky notes (66)
4. Paper form with spaces for the needed information (53)
5. Checklist (64)
6. Electronic form with spaces for the needed information (74)
7. Rely on training and experience (88)
8. None (1)

6. Rank the information you use to prioritize maintenance activities?

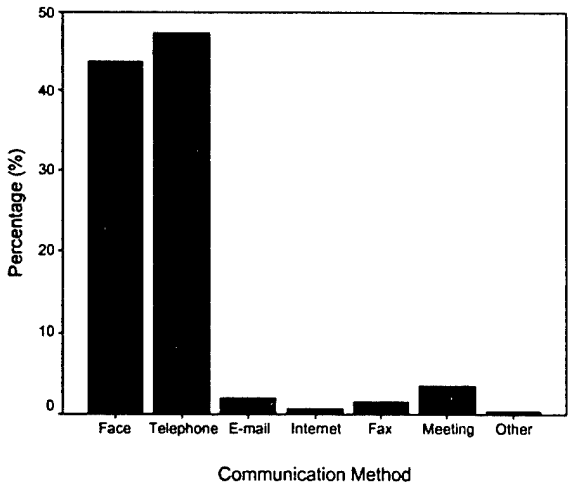
The major consideration for prioritization of maintenance was about the air traffic situation (Item 10). This was followed by the effect of this maintenance activity on adjacent facilities (Item 8) and other events (Item 7), and checking if the current activity is corrective or preventive maintenance (Item 6). The expected weather is also considered (Item 5). However, the expected time to complete the task was not considered highly in prioritizing the tasks (Item 4).



1. Would staff be available if an alternative time was needed (77)
2. Level of airport (62)
3. Impact on requestor (AF) if the event was not approved at the time requested (83)
4. How long does it take to complete the event (82)
5. Expected weather conditions at the time of scheduled event (85)
6. Is the scheduled event to do corrective maintenance or routine preventive maintenance (84)
7. Are there other events scheduled that this event would impact (87)
8. Status of adjacent facilities (82)
9. Other (Please specify.) (4)
10. Is it a good time in terms of air traffic (88)

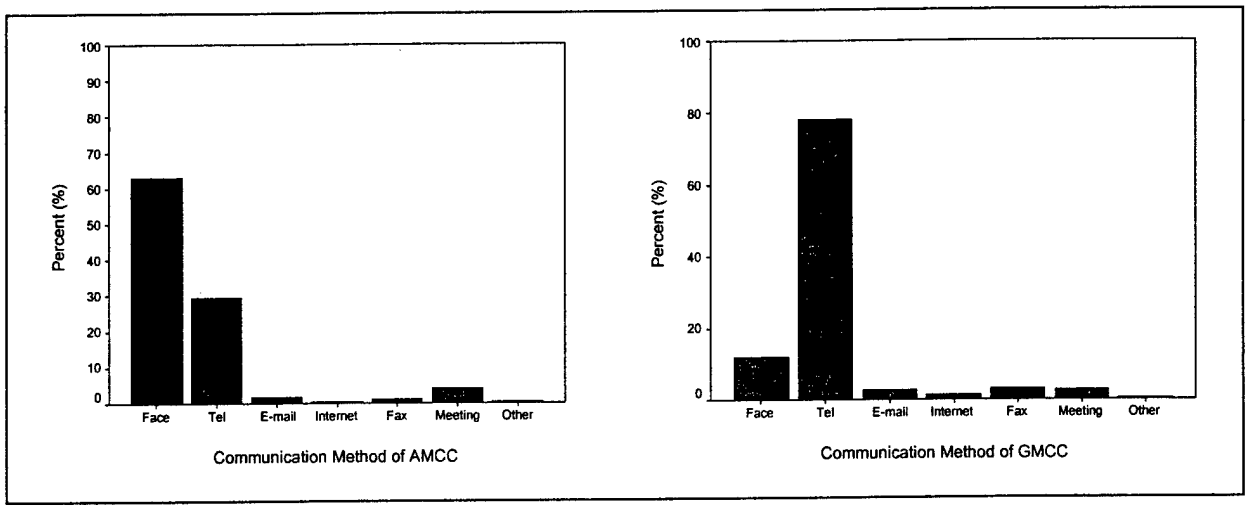
7. When you coordinate with AT personnel, what percentage of the time do you use the following communication methods?

The respondents' communication methods are mostly either face-to-face (Item 1) or telephone (Item 2). Other electronic communication methods such as e-mails were not used often.



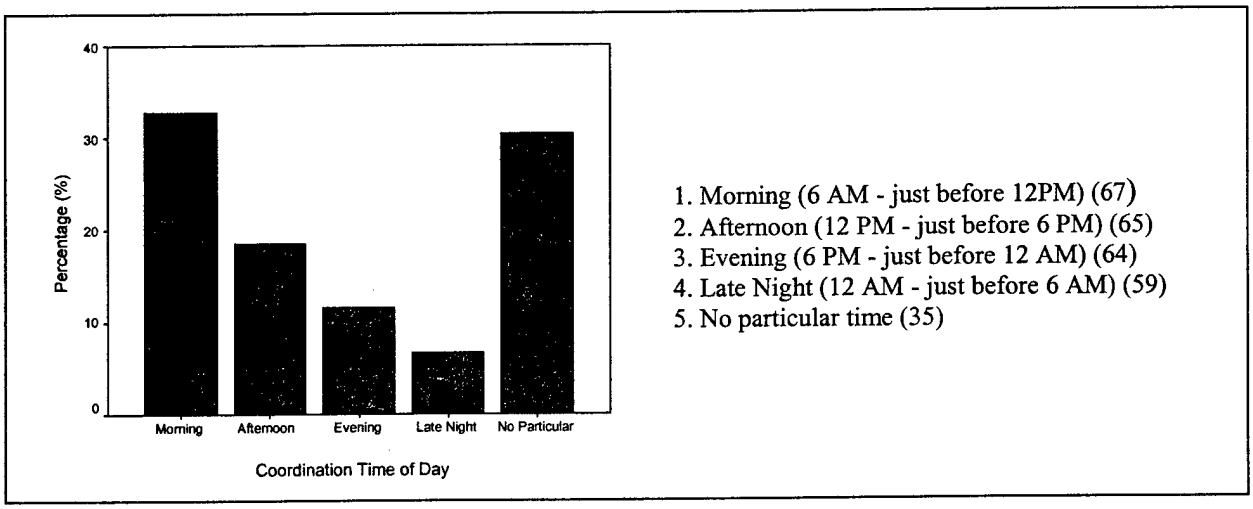
1. Face-to-face conversation (70)
2. Telephone (80)
3. E-mail (31)
4. Internet (10)
5. Fax (23)
6. Formal briefing or regularly scheduled meeting (45)
7. Other (Please specify.) (2)

The graphs below clearly show the major difference in communication methods between AMCC and GMCC personnel. Personnel of the AMCCs, which are collocated with ARTCCs, communicated face-to-face most often. This contrasts with the communication method of personnel at GMCCs, which usually are not collocated with AT facilities, use telephones extensively. Mann-Whitney U test showed that the groups were different in using face-to-face (p <. 01), telephone ($p < .01$), and Internet ($p < .05$). There was no significant difference in using other communication methods between the two groups.



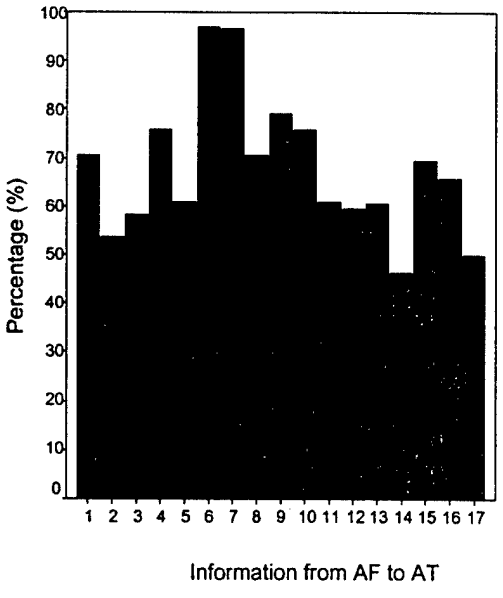
8. What time of day do you coordinate with AT personnel? (Percentages (%) should add to 100.)

Coordination can occur at any time in a day (Item 5), but mostly it occurs in the mornings (Item 1).



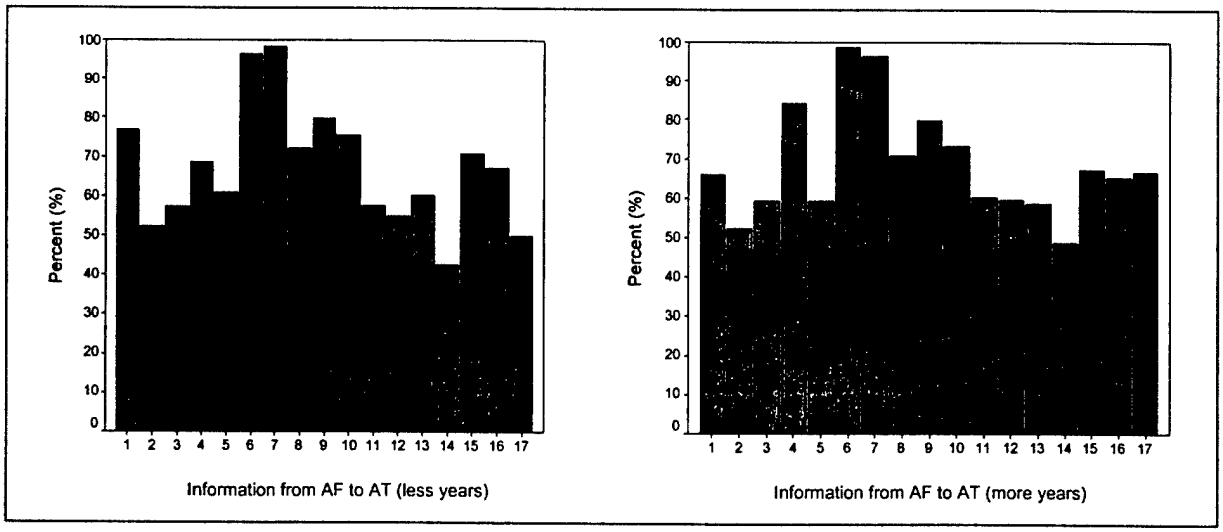
9. What percentage of time do you provide the following information to AT when requesting release for maintenance?

AF provided all information in the list to AT more than half of the time except Item 14 (46%). The information of date and time of the event (Item 6) and the expected duration of the event (Item 7) were provided to AT most of the time (97% for both information).



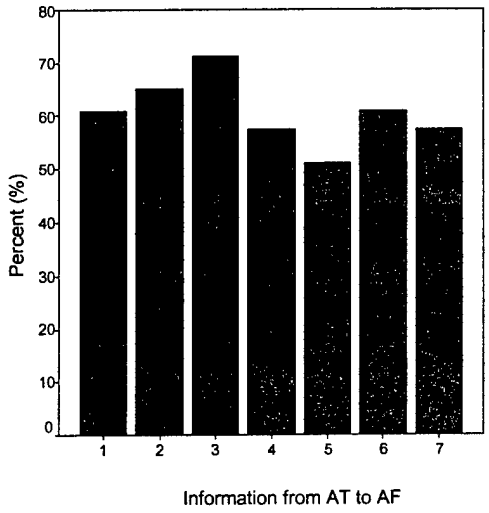
1. Requesting organization (91)
2. What the system's function is within the NAS (91)
3. The criticality of a system or service (90)
4. Backup systems available (89)
5. Other current maintenance activities (90)
6. Date and time of event being coordinated (94)
7. Expected duration of event being coordinated (92)
8. Time needed to return to service in case of emergency (94)
9. AT facilities impacted (93)
10. Why maintenance is needed (94)
11. Consequences if maintenance doesn't occur (e.g., if the window for maintenance is closed) (91)
12. Procedures for AT to contact AF if immediate restoration should be necessary (92)
13. Resources currently being applied to resolve the problem (92)
14. Additional resources needed to perform the maintenance (90)
15. Other scheduled events that this event would impact (92)
16. Status of adjacent facilities (91)
17. Other (Please specify.) (10)

The following graphs show the results for this question for less and more experienced AF personnel at the current MCC positions they held. To categorize them into two groups, we first found the median value of the years all AF personnel worked at the position. It was 4.5 years. This median year divided the group into two equal numbers of people, that is, more experienced and less experienced, based on the years of their experience at the current position. The overall patterns of both groups are similar except the less experienced personnel gave AT the information of "requesting organization" (Item 1) more often than more experienced personnel (77% vs. 66%). In contrast, more experienced personnel provide the information about the availability of backup systems (Item 4) to AT more often than less experienced personnel (69% vs. 84%). Mann-Whitney U test showed that the groups' difference on this item was significant ($p < .05$). For all other items, there was no significant difference between two groups.



10. What percentage of time does AT provide the following information to you when you are coordinating maintenance activities?

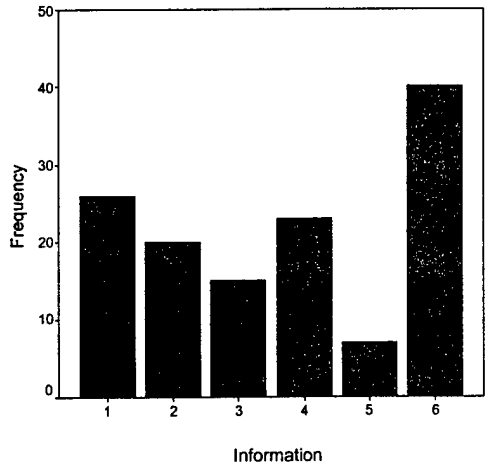
All of the information represented in the above items were provided by AT to AF more than half of the time. The information about backup systems (Item 5) was the least reported information (50%).



1. Current and expected traffic conditions (95)
2. Current and expected weather conditions (94)
3. Chances for approval at the requested time (95)
4. Alternate time or times available (95)
5. Backup systems required (93)
6. Special events (e.g., VIP flights, shuttle launch, air show) (92)
7. Other (Please specify.) (10)

11. Is there additional information from AT that is NOT currently provided to you that would benefit coordination?

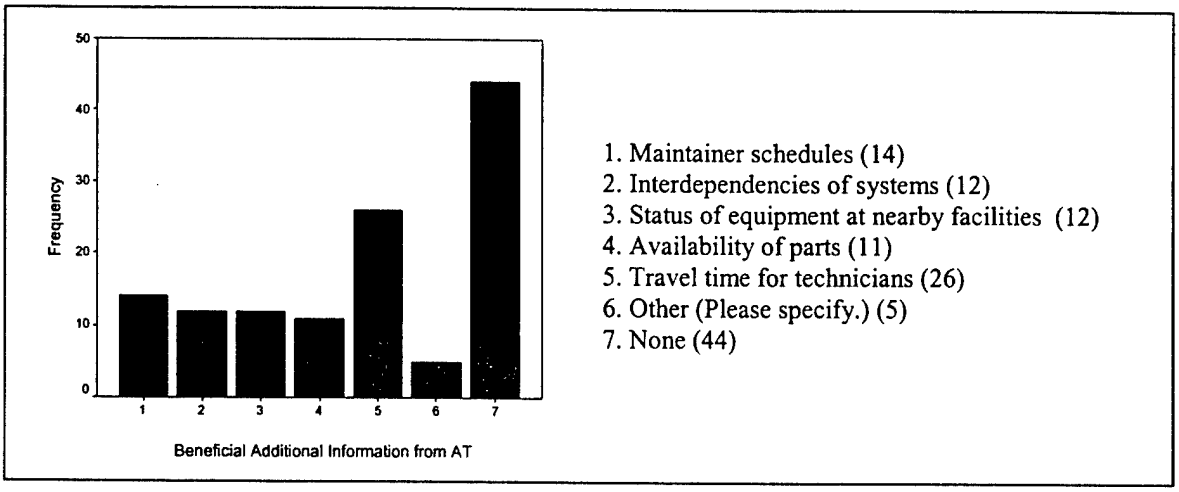
The number of responses to this question was low (see the frequencies in parentheses). The maximum possible frequency was 95 as the same to all other AF questions. About 20% of the AF respondents thought the information presented in this question, that is, air traffic flow, weather in real-time, availability of back-up systems, and special events, would be useful for their coordination.



1. Real time depiction of aircraft flow (26)
2. Real time depiction of weather (20)
3. Backup systems required (15)
4. Special events (e.g., VIP flights, space shuttle launch, air show) (23)
5. Other (7) (Please specify.)
6. None (40)

12. Is there additional information that is NOT currently provided to AT that would benefit coordination?

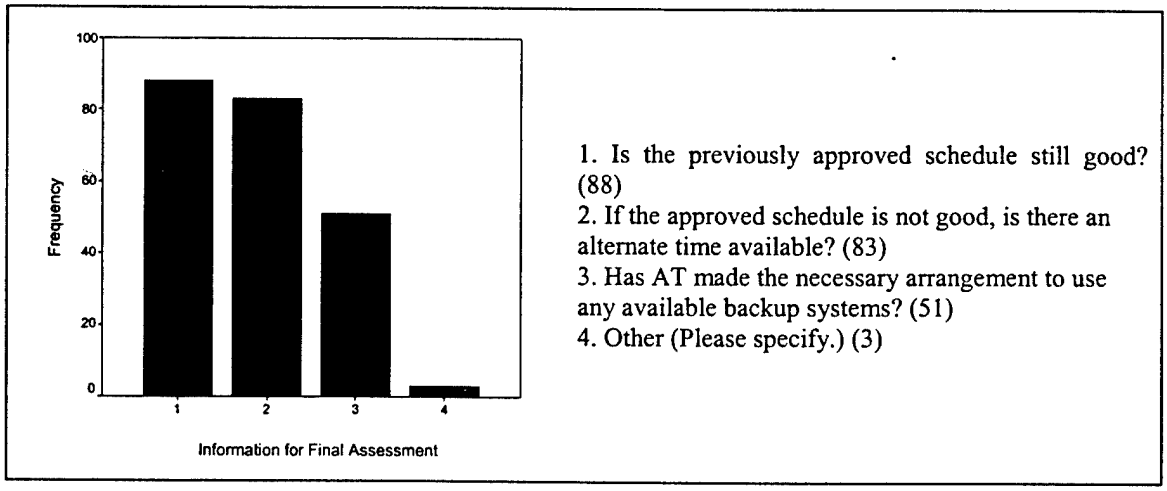
The response frequency of AF respondents was very low for this question. The maximum possible frequency was 95. Twenty-six respondents thought the information of technician's travel time would benefit coordination with AT.



B. Scheduled Event Coordination

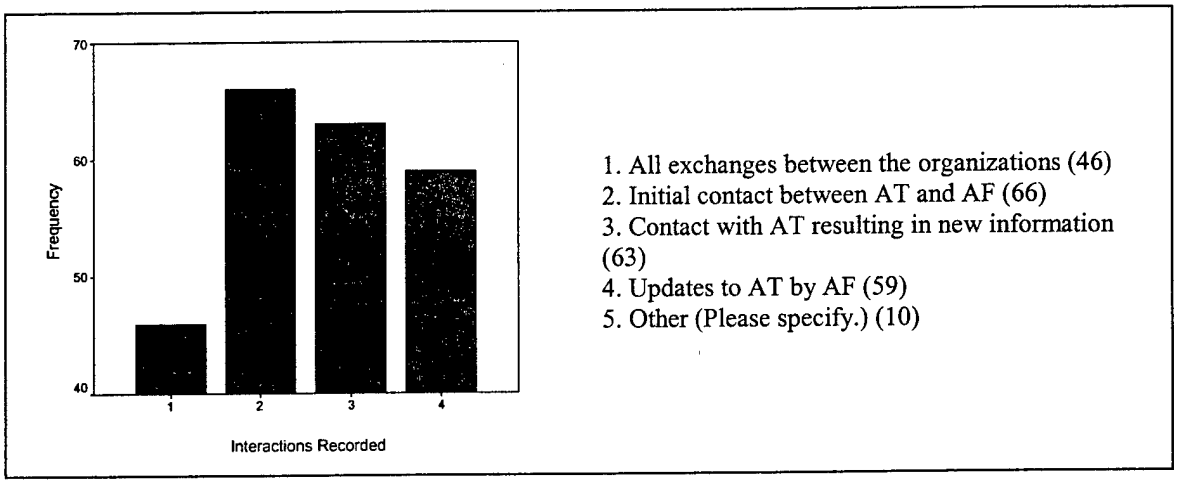
1. When performing the final assessment for release for Scheduled Events, what information do you collect from AT personnel?

To assess the release, most of the AF respondents thought they needed the information of the previously approved schedule (Items 1 and 2). To a lesser degree, 53 respondents (23% of the total respondents who answered this question) wanted to know if AT made an arrangement for a backup system (Item 3).



2. What Scheduled Event interactions with AT are currently recorded?

AF recorded interactions between them and AF (Items 2, 3, and 4) more often than other interactions (Item 1). Updates to AT by AF were not recorded as often as the other kinds of interactions between them.



3. On average, how much in advance do you usually inform AT personnel of a Scheduled Event for short-term (less than 5 hours to complete) maintenance?: 1 day 10 hours 20 minutes

4. On average, how much in advance do you usually inform AT personnel of a Scheduled Event for long-term (5 or more hours to complete) maintenance?: 8 days 8 hours 14 minutes

5. On average, how soon do you usually receive either approval or disapproval responses from AT for a short-term (less than 5 hours to complete) Scheduled Event?: 6 hours and 27 minutes

6. On average, how soon do you usually receive either approval or disapproval responses from AT for a long-term (5 or more hours to complete) Scheduled Event?: 2 days 5 hours 31 minutes

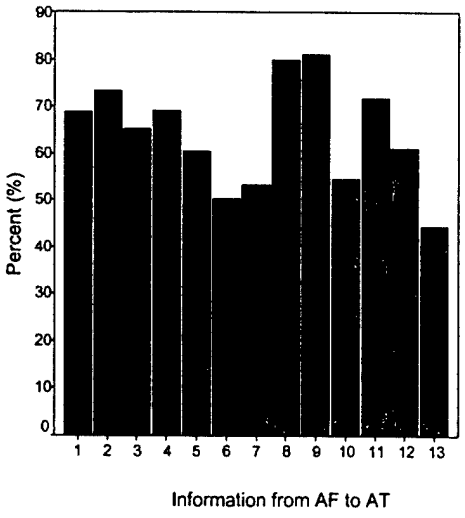
7. What percentage of time does AT ask to reschedule a Scheduled Event?: 20.1%

C. Unscheduled Event Coordination

1. What percentage of time do you provide the following information to AT as you coordinate Unscheduled Events?

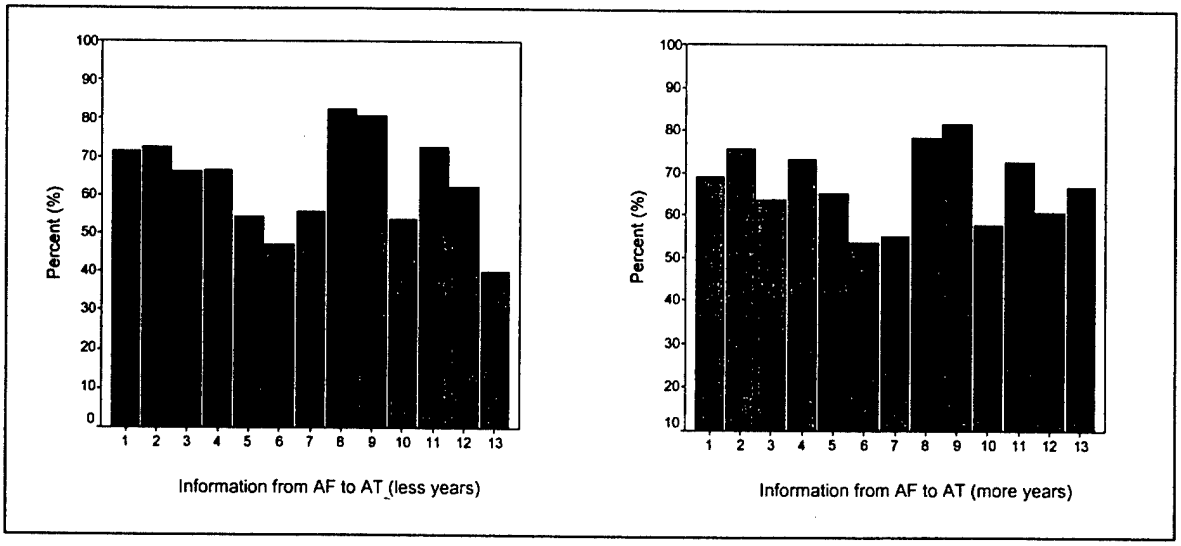
The most frequently provided information to AT by AF was what equipment and services were affected (Item 8) and the cause of event (Item 9). Items 2 and 9 were about events and were reported to AT quite frequently. The information on facilities (Items 3 and 4) and parts (Items 3, 4, and 12) was also frequently provided. The expected restoration time (Item 1) was one of the most frequently provided information to AT. The information on activities to restore (Item 5) and frequency of status updates (Item 7) may be categorized as background information and was not provided to AT often. Also, in general, the information about staff (Items 6, and 10) was not

reported as often as the other information except the information on the status of technicians who work on the current maintenance (Item 11).



1. Expected restoration time (93)
2. Are there other events scheduled that this event would impact? (e.g., Scheduled Events that may need to be cancelled) (92)
3. Status of adjacent facilities (93)
4. When are the other facilities expected to be returned to service (RTS) (93)
5. Activities needed to restore (92)
6. Availability of staff if an alternate time is needed (91)
7. Frequency of status updates (90)
8. Equipment and services affected (90)
9. Cause of event (93)
10. Availability of technicians with necessary skills (93)
11. Status of technicians (e.g., on site, en route, expected arrival time) (92)
12. Status of needed parts (e.g., availability) (94)
13. Other (Please specify.) (9)

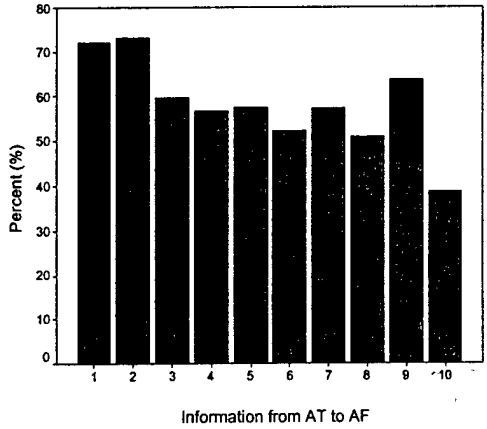
The following graphs show the results for this question for less and more experienced AF personnel at the current MCC positions they held. To categorize them into two groups, we first found the median value of the years all AF personnel worked at the position as we did for Section A, Question 7 previously. Mann-Whitney-U test showed that these two groups were not significantly different each other on any items.



2. What percentage of time does AT provide the following information to you as you coordinate Unscheduled Events?

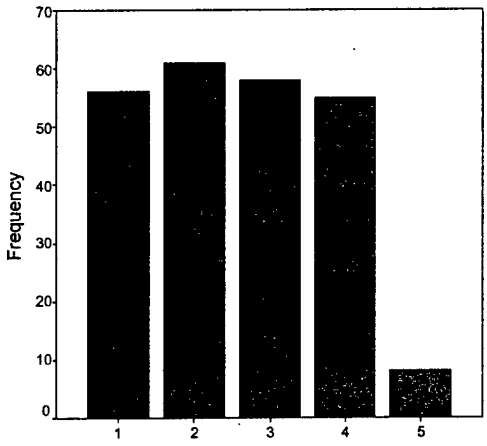
All of the information represented by the items was provided quite frequently as shown in the graph (above 50%). The most frequently reported information was about the potential impact on

NAS operations and traffic (Items 1, 2, and 9). The information about backups (Items 6 and 8) was not provided as frequently as the other information.



1. Potential impact on NAS operations (93)
2. Potential traffic delays (93)
3. Restoration time requirements (92)
4. Relative importance to the flow of traffic at other facilities (92)
5. Current and expected weather conditions (93)
6. Backup systems or procedures in use during the time of the event (92)
7. Special conditions that may be impacted (e.g., VIP flight) (92)
8. How well the transition to backup proceeded (92)
9. Air traffic restrictions implemented (92)
10. Other (Please specify.) (11)

3. What Unscheduled Event interactions with AT are currently recorded?
All of the information represented in the items was recorded more than half of the times (above 50%).



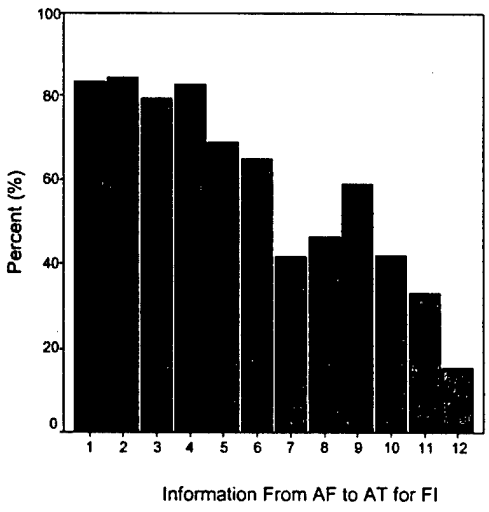
1. All exchanges between the organizations (56)
2. Initial contact between AT and AF (61)
3. Contact with AT resulting in new information (58)
4. Updates to AT by AF (55)
5. Other (Please specify.) (8)

4. How soon do you usually receive responses from AT, either approval or disapproval, for an Unscheduled Event? : 2 hours and 41 minutes.

D. Flight Inspection (FI) Coordination:

1. What percentage of time do you provide the following information to AT as you coordinate Flight Inspections?

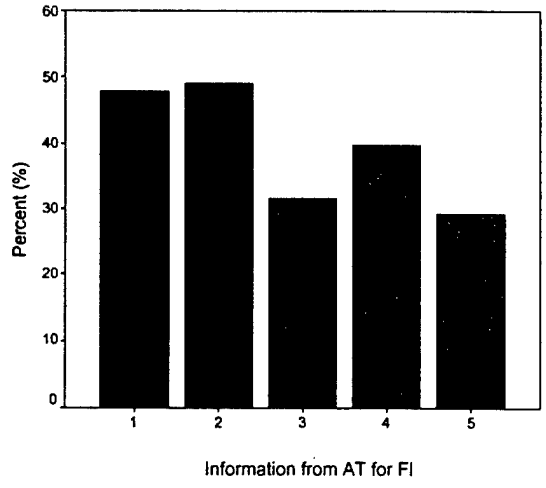
The specific information of the flight inspection (Items 6 [type of interaction] and 9 [consequences if not completed]) and facilities and systems (Items 1, 3, and 4) was the most frequent information AF provided to AT. The information about time (Items 2 and 5) was also quite frequently provided to AT. The other information (Items 7, 8, 10, and 11) was not provided as often (less than 50%).



1. The facility being inspected (79)
2. The time requested by AF and FI personnel (78)
3. The identifier (77)
4. Runway number (if ILS system) (76)
5. Estimated length of the inspection (77)
6. The type of inspection (e.g., routine, post accident, or a commissioning FI) (78)
7. Whether AT person needs to be designated for entire FI (77)
8. Preferred alternative schedule if required (77)
9. Consequences of not being able to complete the FI (76)
10. FI aircraft tail number (77)
11. Pattern of flight in airspace. (e.g., circling in a particular area, landing, etc.) (77)
12. Other (Please specify.) (13)

2. What information does AT provide to you as you coordinate Flight Inspections?

The most frequently provided information from AT to AF was about traffic whether the traffic condition would change during scheduled time (Item 1) and the effect of maintenance on traffic flow (Item 2) (about 50% for both items).

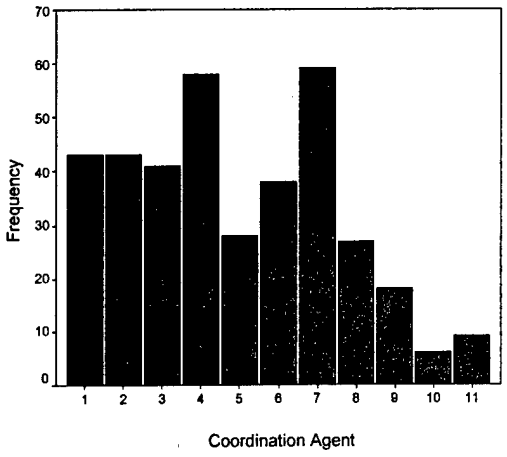


1. Expected traffic conditions at time of scheduled FI (79)
2. Effect on traffic flow (80)
3. Availability of AT personnel to help FI if needed (80)
4. Are interruptions to the FI possible (e.g. due to traffic) (80)
5. Other (Please specify.) (18)

3. With whom do you coordinate when closing out a flight inspection event (e.g., if a NOTAM is issued or cancelled)?

AF contacted FSS personnel (Item 4) and AF field technicians (Item 7) most often to coordinate the closing of the flight inspection event, about 60% for both. They also contacted other AT and

AF personnel at other AF and AT facilities (Items 1, 2, 3, and 6) more often than NOCC (Item 5), flight inspection personnel (Item 8), and military contacts (Item 9).

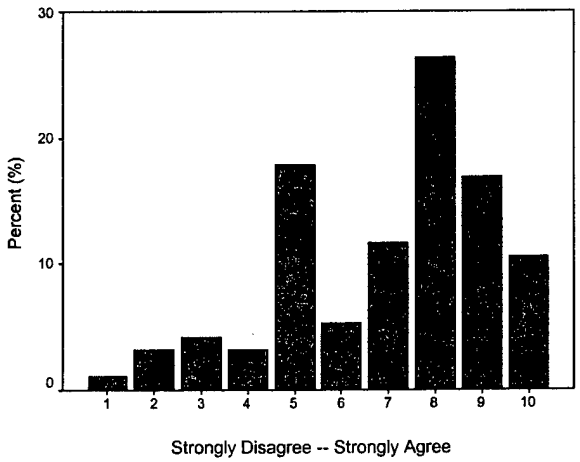


1. AT Tower personnel (43)
2. AT TRACON personnel (43)
3. AT Center personnel (41)
4. FSS personnel (58)
5. NOCC (28)
6. AF personnel at other facilities (38)
7. AF field technicians (59)
8. Flight inspection personnel (27)
9. Military contacts associated with joint use facilities (18)
10. Other (Please specify.) (6)
11. None (9)

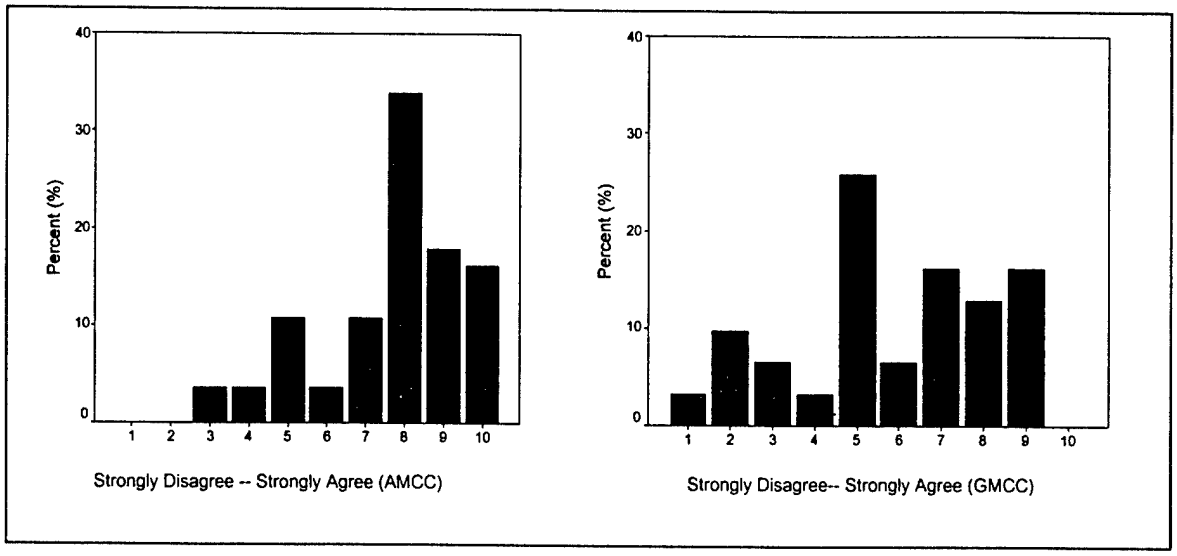
E. Your Opinion

All of the 95 respondents completed the following questions in this section except that some did not fill out the open-ended Questions 4, 5, and 6.

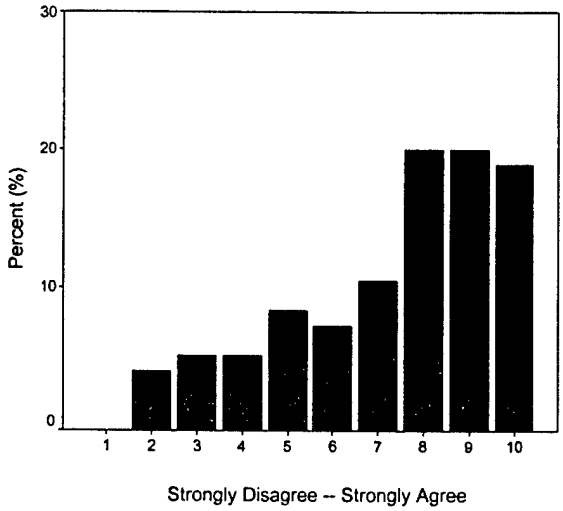
1. Current response times to maintenance requests are adequate.
The mean score was 7.0. Overall, the respondents moderately agreed with the statement that current response times to maintenance requests were adequate.



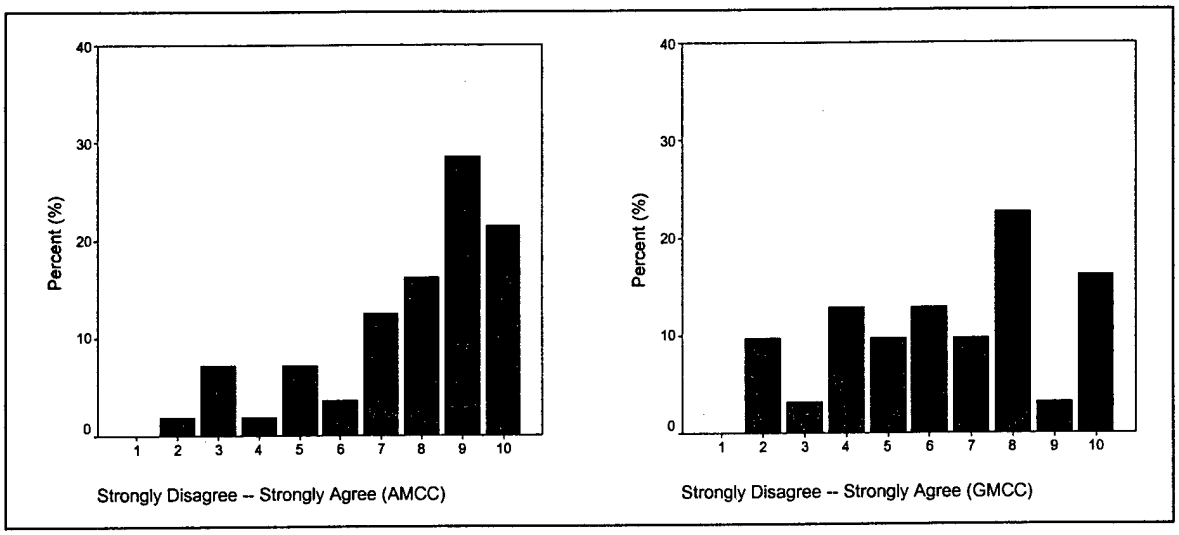
The mean ratings for AMCC and GMCC were 7.7 and 5.8, respectively. Overall, more AMCC than GMCC personnel thought the AT's response time was adequate. The independent t tests showed a significant difference between the two groups, $t\ (51) = 3.74$, $p < .01$; the degrees of freedom was adjusted because the equal-variance assumption of the two groups' distributions was rejected. Without the adjustment, it should have been 85.



2. There are clearly defined roles for coordinating with AT.
The mean score was 7.3. The AF personnel agreed moderately that there were clearly defined roles in coordinating with AT.

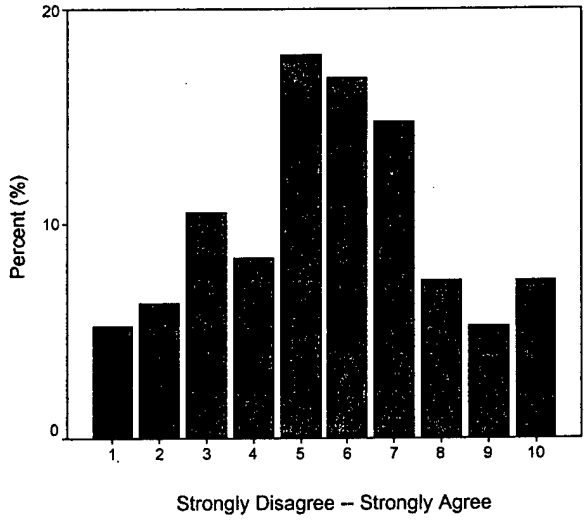


The means of AMCC and GMCC ratings were 7.8 and 6.5, respectively. The *t* test showed their rating patterns were significantly different, $t\ (85) = 2.55, p < .05$. AMCC personnel agreed with the statement of the question more strongly than GMCC personnel.

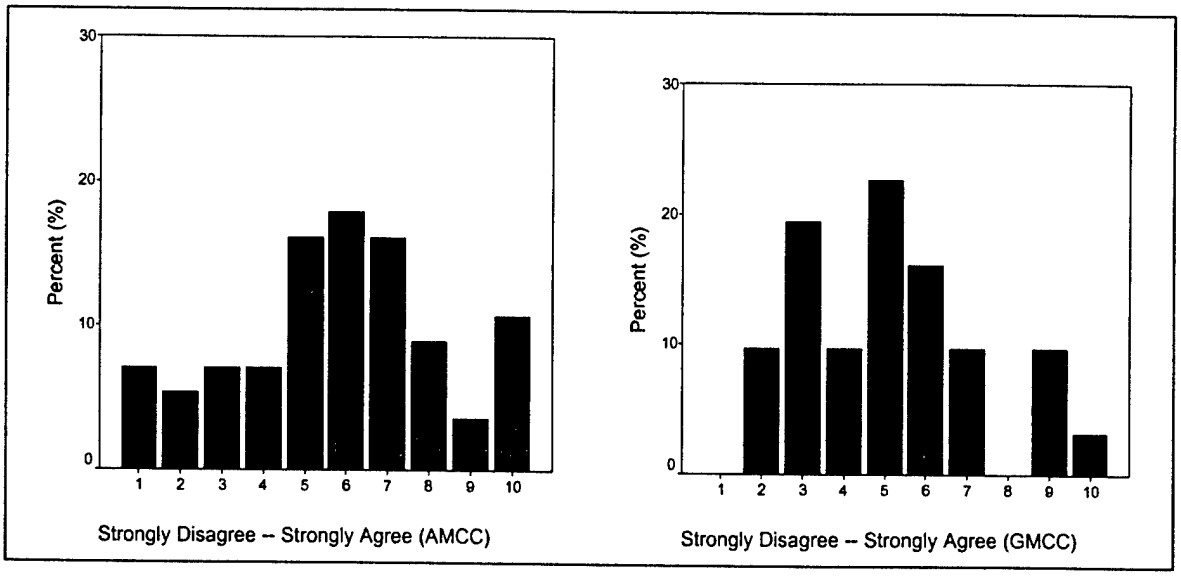


3. There are mechanisms in place to detect inappropriate decisions (to accept/deny maintenance).

The mean score was 5.6. This is close to the neutral position (score 5.5), that is, they did not either agree or disagree with the statement above.



The mean AMCC and GMCC ratings were 5.8 and 5.1, respectively. Both groups' ratings were close to the neutral rating, that is, 5.5. Their rating patterns were not significantly different, t (85) = 1.22, $p > .05$.



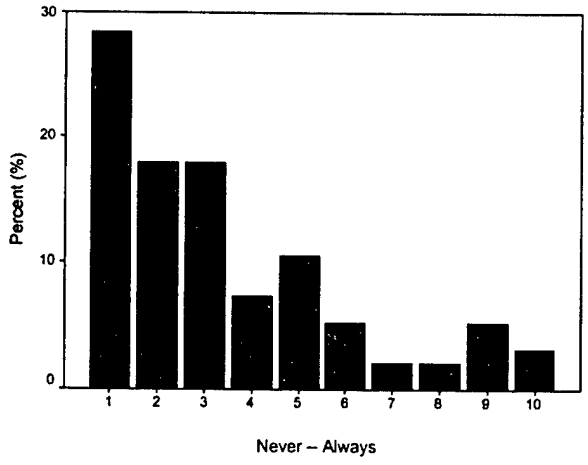
4. What are the most successful aspects of current AF/AT coordination? (The results of this question are summarized in Appendix E.)

5. Please describe any obstacles you currently face with coordination. (The results of this question are summarized in Appendix E.)

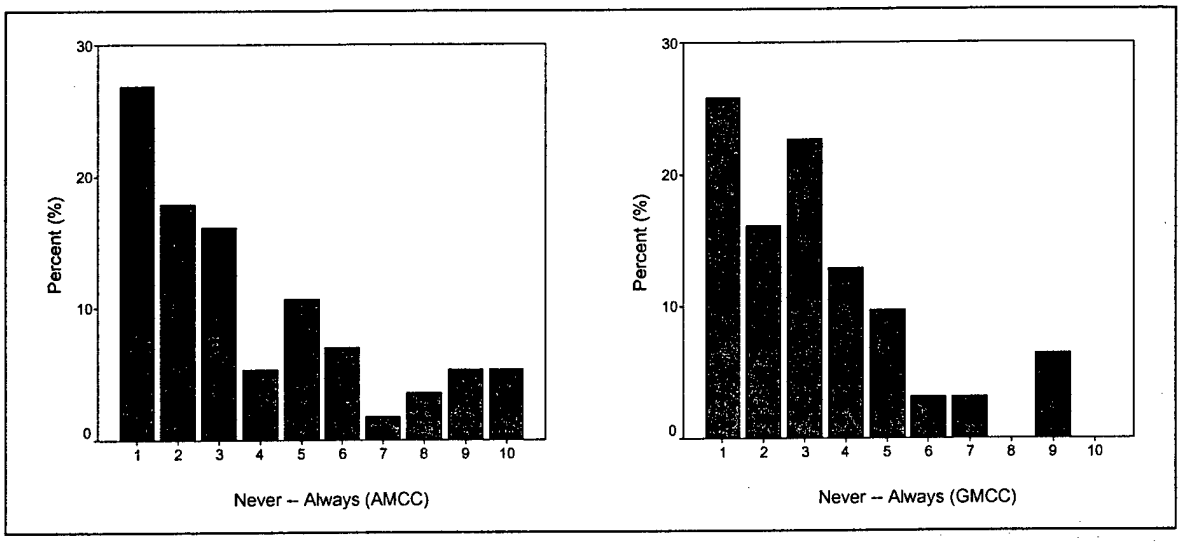
6. Describe any suggestions you have for improving the current coordination process with AT. (The results of this question are summarized in Appendix E.)

7. How often do AT personnel prioritize your maintenance tasks for you?

The mean score was 3.4, which means that AT rarely prioritized AF's tasks.

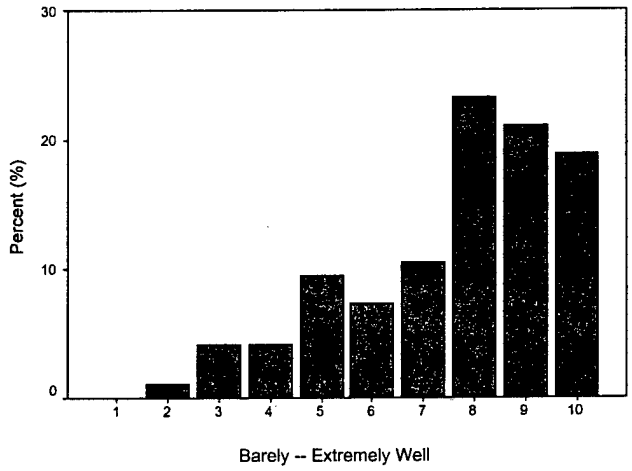


The mean ratings by AMCC and GMCC personnel were 3.7 and 3.3, respectively (see graphs below). They were not significantly different, $t\ (85) = .79, p > .05$.

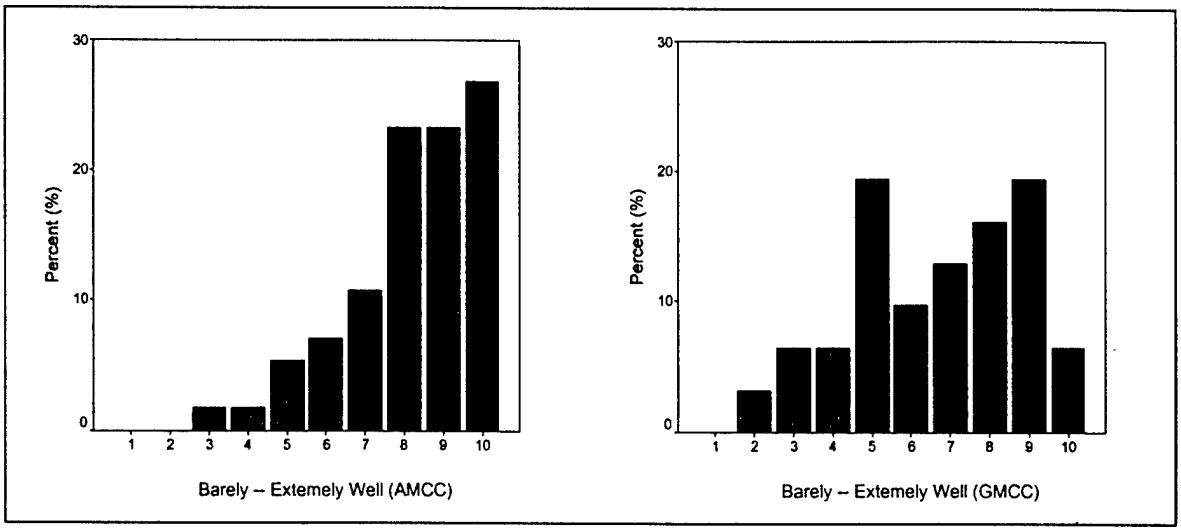


8. How thoroughly do you understand AT tasks and responsibilities?

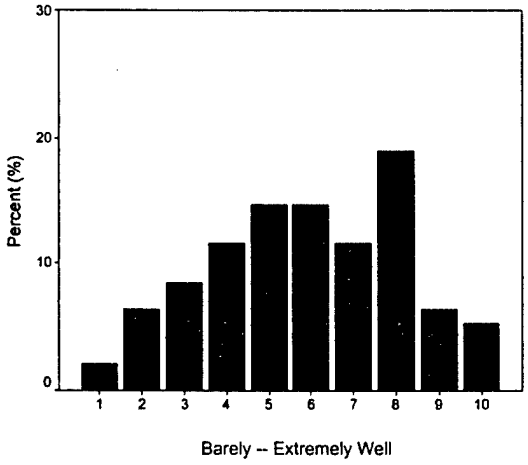
The mean score was 7.6. This means that AF personnel thought that they understood AT tasks and responsibilities to some extent.



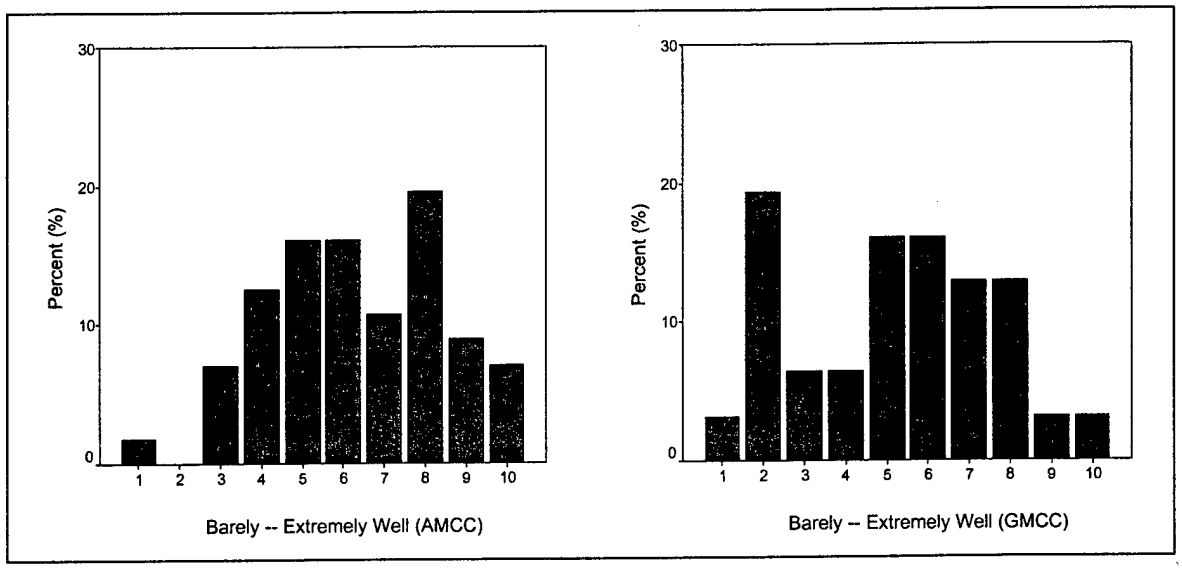
The mean rating scores for AMCC and GMCC were 8.2 and 6.6, respectively. More AMCC than GMCC personnel thought they understood AT tasks and responsibilities better. This difference was significant, $t\ (50) = 3.40$, $p < .01$. The degree of freedom was adjusted because the equal-variance assumption of the two groups' distributions was rejected. Without the adjustment, it should have been 85.



9. How thoroughly do you think AT personnel understand your roles and responsibilities?
The mean score was 6.0, which was close to the neutral position (score 5.5). AF personnel believed that AT personnel did not understand AF's roles and responsibilities well.

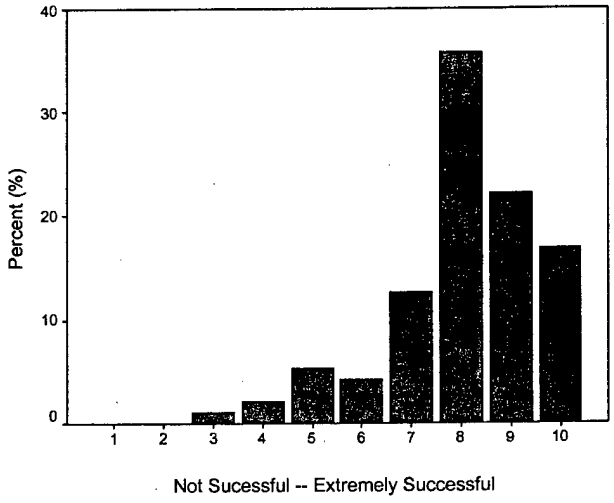


Both AMCC and GMCC groups gave low ratings to this question. AMCC and GMCC personnel gave 6.3 and 5.2 in average, respectively. However, more AMCC than GMCC personnel thought the AT counterpart understood AF's roles and responsibilities. The groups' rating patterns were significantly different, $t\,(85) = 2.29$, $p < .05$.

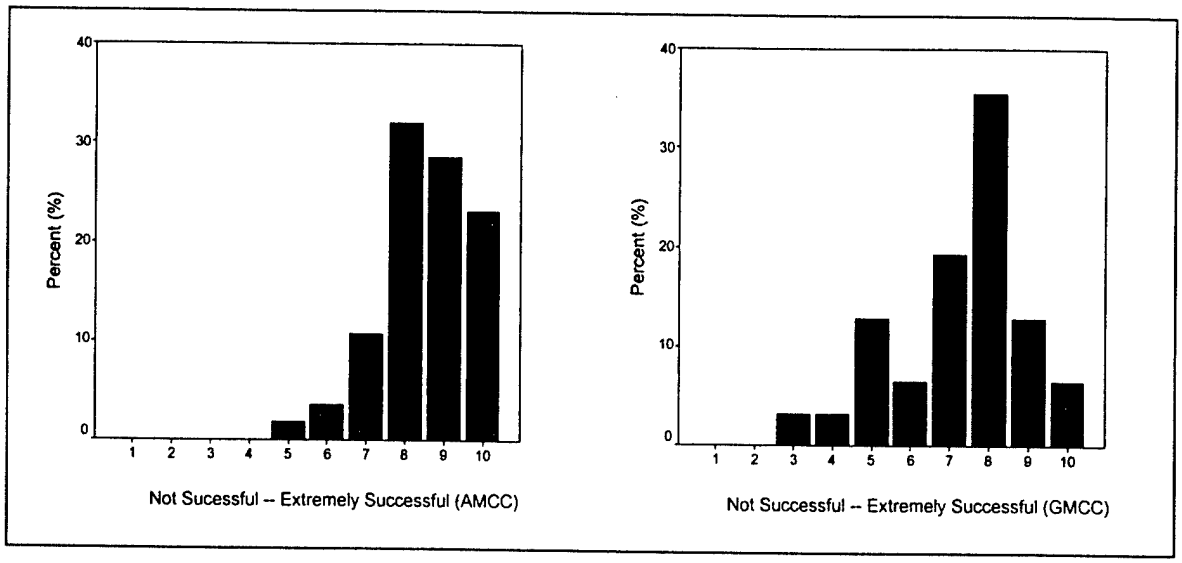


10. How successful is current AT/AF coordination?

The mean score was 8.1. This means that AF personnel thought that the current AF/AT coordination was successful to some extent.



The mean ratings of AMCC and GMCC personnel were 8.5 and 7.3, respectively. Their ratings were significantly different, $t\ (46) = 3.68, p < .01$. The degrees of freedom was adjusted because the equal-variance assumption of the two groups' distributions was rejected. Without the adjustment, it could have been 85. AMCC respondents considered the current coordination more favorably than GMCC respondents.


Percent (%)
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10
Not Sucessful -- Extremely Successful (AMCC)
Percent (%)
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10
Not Successful -- Extremely Successful (GMCC)

APPENDIX D

AT Results

AT Results

In the following, we summarized the data of the questions except the demographic data (see the Appendix B for the full descriptions of AT questionnaire). The results of demographic data were presented in the previous Results section of this report. In the following graphs, the numbers in the parentheses by the legend items are the number of valid responses, i.e., the total number of participants who responded to that particular item. Usually the number of participants who responded to "Other" was small. Because of that, we did not discuss the data for this "Other" unless there were any significant facts to report. For each question, the number of respondents for each question varied. The possible maximum number was 179 because the data of 179 AT personnel were used for the analysis.

For Section A, Questions 1, 2, 3, and 4, we tabulated the frequency of items being ranked first by respondents because the averaged data did not show a clear picture. This number is presented in the second parentheses by each legend.

As shown in the results of AF data, the collocation of AMCCs and ARTCCs mattered for the efficient coordination. To test this from the perspectives of AT, we divided data of Section 1, Questions 1 and 2 and Section E, Questions 1, 5, 6, and 7 into ARTCC respondents' and non-ARTCC respondents' and compared the two groups' data for each question. We identified 119 ARTCC and 49 non-ARTCC respondents among 179 respondents.

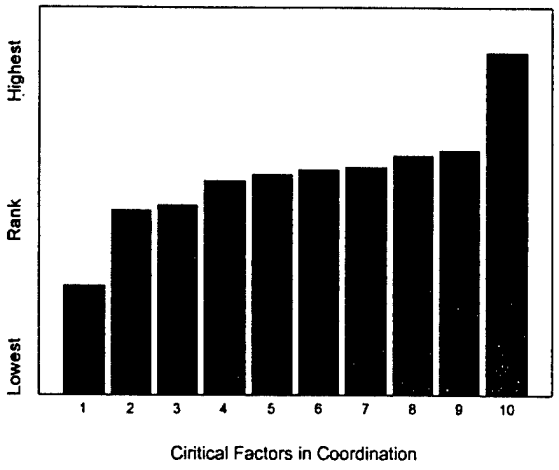
In the following graphs for rank data, even though respondents used smaller numbers to designate higher ranks (such as 1 as the highest), we showed high ranks as high bars in the graphic representation. For this purpose, we subtracted the raw ranks from the total number of items in the question and used these new numbers for graphic representation. We ordered the items by rank on the x-axis.

A. Overall coordination

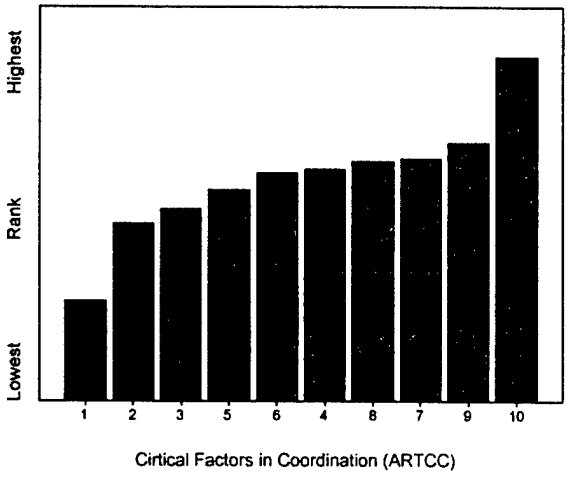
1. Rank the most critical factors for effective AT/AF coordination.

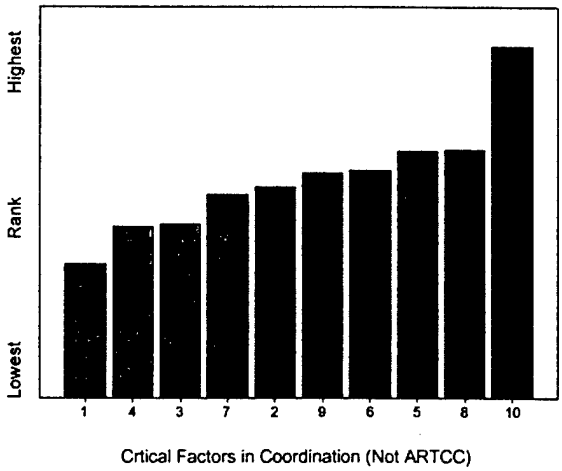
All of the factors were ranked similarly except the Item 1 ("Personality of AF person"). The "Other" factor was ranked high but only six respondents used it. To explore the data to see if there were any meaningful differences between the factors, we tabulated the frequency of how many times each factor was ranked first. The results showed that Item 9 ("Established relationship between AT and AF"), Item 8 ("Well established coordination procedure"), Item 7 ("AT's understanding of what is wrong with the equipment"), and Item 5 ("Getting to the right AF person") were very important to many respondents. (Please see the second numbers by the items.)

When we tested if ARTCC and non-ARTCC respondents' ranks were significantly different using the non-parametric Mann-Whitney U test, we found personnel at non-ARTCCs rated Item 9 (""Established relationship between AT and AF") ($p < .5$), Item 5 ("Getting to the right AF person") ($p < .05$), and Item 2 ("Workload of AF person") ($p < .05$) significantly higher than the personnel at ARTCCs. Personnel at ARTCCs rated Item 4 ("Using the same terminology") significantly higher than the personnel at non-ARTCCs ($p < .01$).



1. Personality of AF person (129) (1)
2. Workload of AF person (e.g. is he/she busy with other duties) (147) (8)
3. Understanding and appreciating the other person's duties and responsibilities (156) (15)
4. Using the same terminology (164) (19)
5. Getting to the right AF person (144) (34)
6. Communication method (157) (11)
7. AT's understanding of what is wrong with the equipment (167) (31)
8. Well established coordination procedures (163) (33)
9. Established relationship between AT and AF (162) (34)
10. Other (Please specify.) (6)

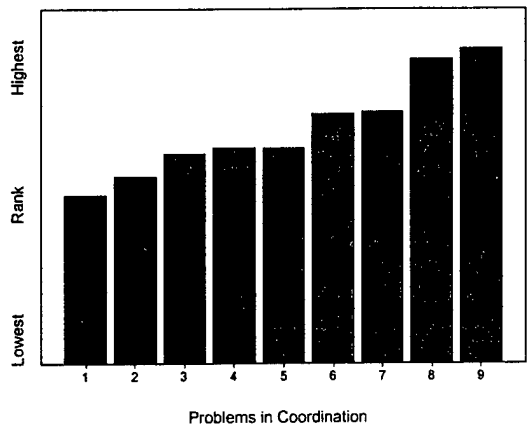




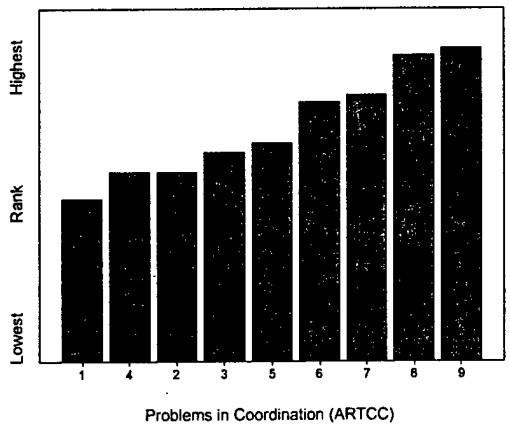
2. Rank the problems you currently face with coordination.

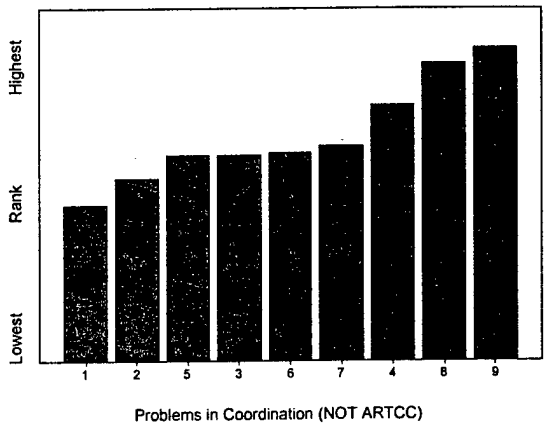
The quality of information (Item 7) and getting the information in sufficient time (Item 6) were the most critical problems in coordination as shown in the graph. The second numbers in parentheses were the frequency of being ranked first as mentioned before. Items 7 and 6 were ranked first by 46 and 23 participants, respectively. Other items were ranked first by fewer participants.

Mann Whitney U test showed that there was a significant difference on Item 7 ("Insufficient or inaccurate information") ($p < .01$), Item 6 ("Not getting information that you need in sufficient time") ($p < .1$), and Item 4 ("Inability to reach the right person") ($p < .01$) between ARTCC and non-ARTCC respondents' ranks.



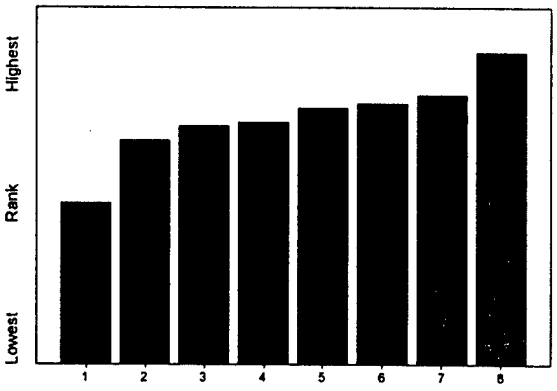
1. Too many groups to coordinate with (63) (8)
2. Communication method (88) (5)
3. Unclear roles (of who should communicate with whom or who should be making decisions) (79) (15)
4. Inability to reach the right person (77) (16)
5. Unclear with whom to coordinate and when (78) (13)
6. Not getting information that you need in sufficient time (99) (23)
7. Insufficient or inaccurate information (115) (46)
8. Other (Please specify.) (15) (12)
9. None (18) (18)





3. Rank how often you use the following memory aids to tell you <u>what information</u> to use for coordination purposes.

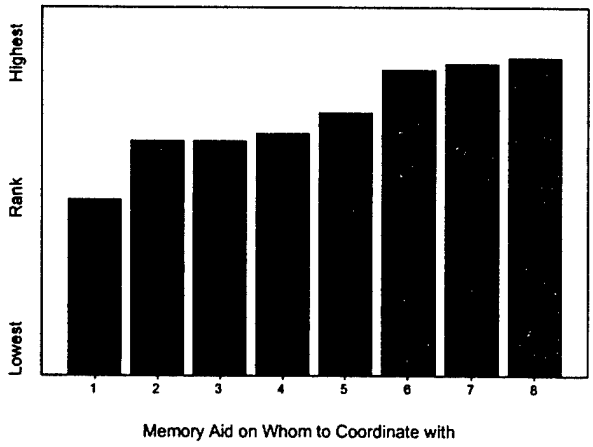
Item 7 ("Relying on training and experience") was the most frequently used memory aid to keep the record of coordination information. It was also ranked number 1 by 68 participants, which was the most.



1. Flowcharts (34) (0)
2. Electronic form with spaces for the needed information (71) (14)
3. Handwritten notes on paper or sticky notes (122) (29)
4. Paper form with spaces for the needed information (96) (29)
5. Checklist (100) (33)
6. Other (Please specify.) (13) (5)
7. Rely on training and experience (145) (68)
8. None (4) (5)

4. Rank how often you use the following memory aids to tell you <u>with whom</u> to coordinate.

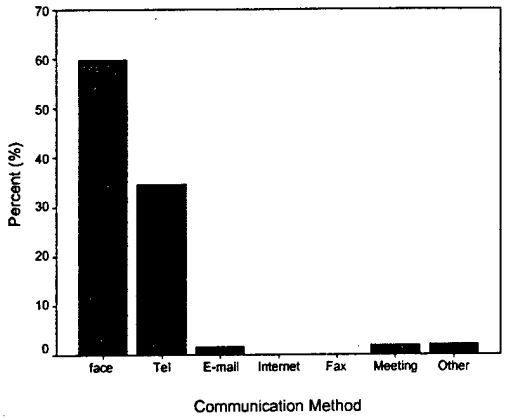
As for the question 3, Item 6 ("Rely on training and experience") was ranked highest for the memory aid to tell with whom to coordinate. This item was ranked first by 103 participants.



1. Flowcharts (27) (1)
2. Handwritten notes on paper or sticky notes (73) (10)
3. Electronic form with spaces for the needed information (48) (9)
4. Paper form with spaces for the needed information (54) (10)
5. Checklist (64) (15)
6. Rely on training and experience (131) (103)
7. Other (Please specify.) (14) (12)
8. None (11) (10)

5. When you coordinate with AF personnel, what percentage of the time do you use the following communication methods? (Percentages (%) should add to 100.)

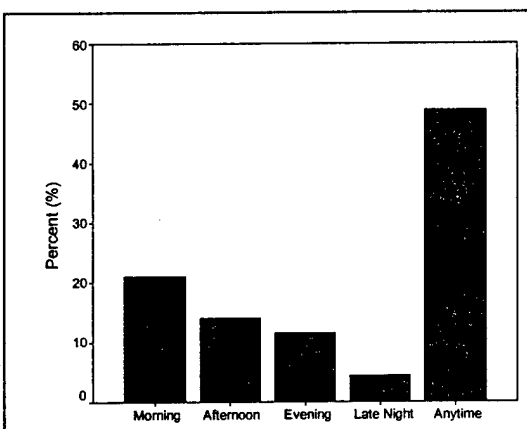
Most of the coordination was done by either face-to-face communication or telephone. E-mail or other electronic communication was not used often.



1. Face-to-face conversation (175)
2. Telephone (157)
3. E-mail (63)
4. Internet (49)
5. Fax (48)
6. Formal briefing or regularly scheduled meeting (66)
7. Other (Please specify.) (26)

6. What time of day do you coordinate with AF personnel?

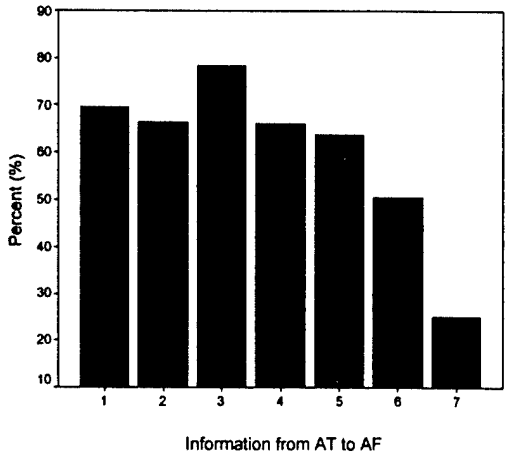
Most of the coordination (about 50%) was done at no particular time of day according to the data. Of the times that were identified, morning was the busiest.



1. Morning (6 AM –just before 12PM)
2. Afternoon (12 PM-just before 6 PM)
3. Evening (6 PM-just before 12 AM)
4. Late Night (12 AM- just before 6 AM)
5. No particular time

7. What percentage of time do you provide the following information to AF when they are coordinating maintenance activities?

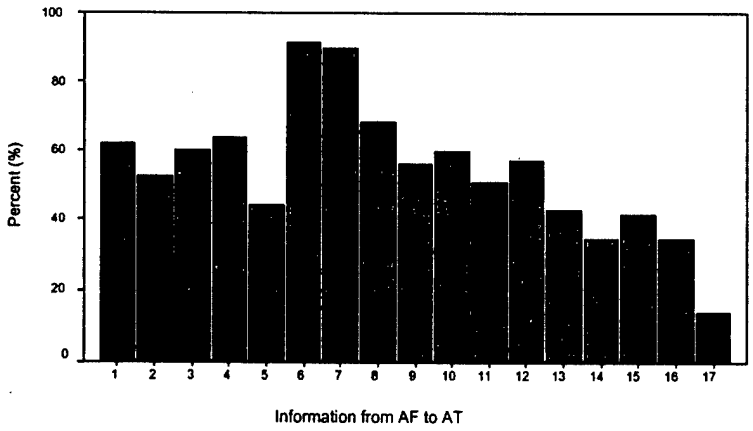
All of the information presented as items in the question was provided to AF more than 60% of the time except the information on special events which was provided about 50% of the time.



1. Current and expected traffic conditions (171)
2. Current and expected weather conditions (171)
3. Chances for approval at the requested time (170)
4. Alternate time or times available (172)
5. Backup systems required (167)
6. Special events (e.g., VIP flights, shuttle launch, air show) (162)
7. Other (Please specify.) (18)

8. What percentage of time does AF provide the following information to you when they are coordinating maintenance activities?

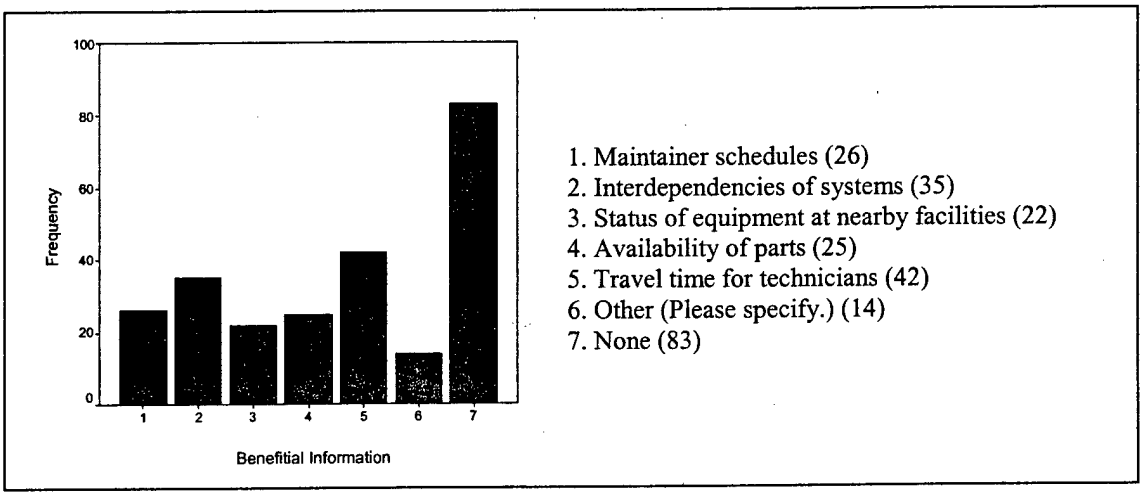
Item 6 ("Date and time of event being coordinated"), Items 7 ("Expected duration of event being coordinated"), and Item 8 ("Time needed to return service in case of emergency") were the information that were mostly provided to AT by AF. All of these are about time for the event.



1. Requesting organization (171)
2. What the system's function is within the NAS (172)
3. The criticality of a system or service (174)
4. Backup systems available (173)
5. Other current maintenance activities (171)
6. Date and time of event being coordinated (176)
7. Expected duration of event being coordinated (174)
8. Time needed to return to service in case of emergency (174)
9. AT facilities impacted (170)
10. Why maintenance is needed (173)
11. Consequences if maintenance doesn't occur (e.g., if the window for maintenance is closed) (174)
12. Procedures for AT to contact AF if immediate restoration should be necessary (174)
13. Resources currently being applied to resolve the problem (172)
14. Additional resources needed to perform the maintenance (171)
15. Other scheduled events that this event would impact (171)
16. Status of other adjacent facilities (167)
17. Other (Please specify.) (11)

9. Is there additional information that is NOT currently provided to you that would benefit coordination?

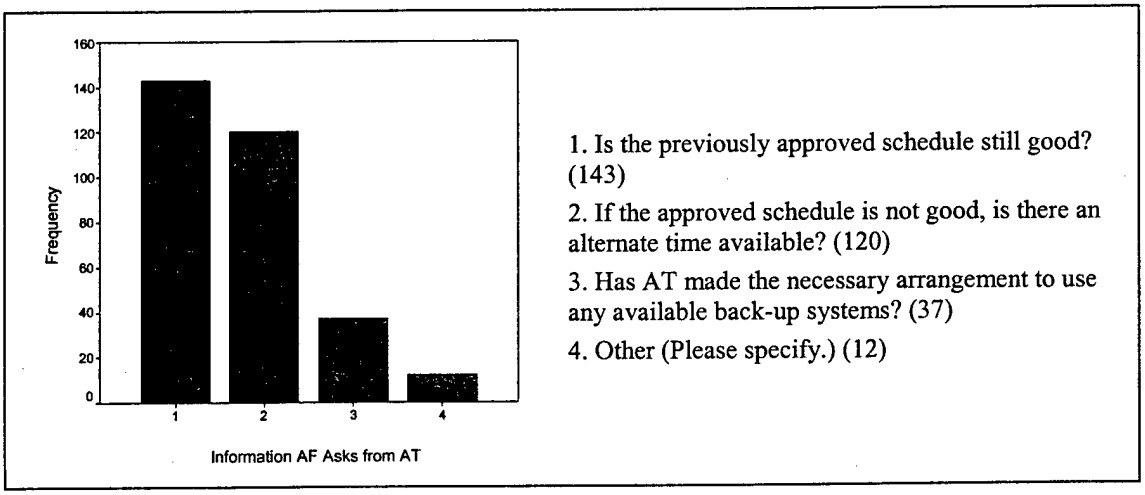
Not many participants responded to this question, from 42 participants for Item 5 ("Travel time for technicians") to 22 participants for Item 3 ("Status of equipment at nearby facilities").



B. Scheduled Event (routine maintenance including equipment shutdown) coordination

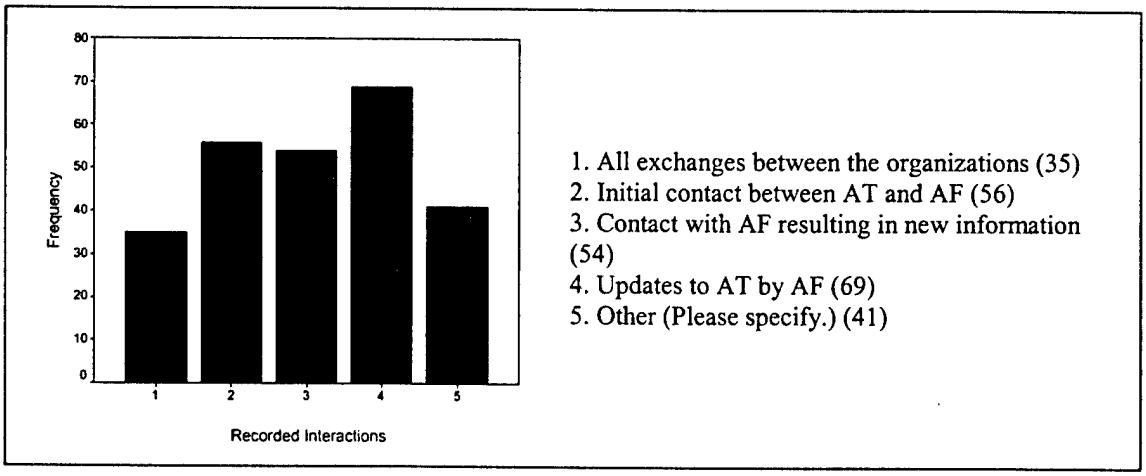
1. Just before releasing something for scheduled maintenance, what information does AF ask from you?

AF requested AT the information about approved schedules (Items 1 and 2) most often. They did not have as much concern on AT's backup preparation.



2. What Scheduled Event coordination interactions with AF do you record? (please circle all that apply)

Not many participants responded to this question. Item 4: Updated to AT by AF was the most frequent interaction they record at about 39%. They recorded all interactions only about 21% of the time.



3. On average, how much lead time do you usually get from AF for a short-term (less than 5 hours to complete) Scheduled Event?: 1 Day 5 hrs 36 minutes

4. On average, how much lead time do you usually get from AF for a long-term (5 or more hours to complete) Scheduled Event?: 5 days 6 hours 39 minutes

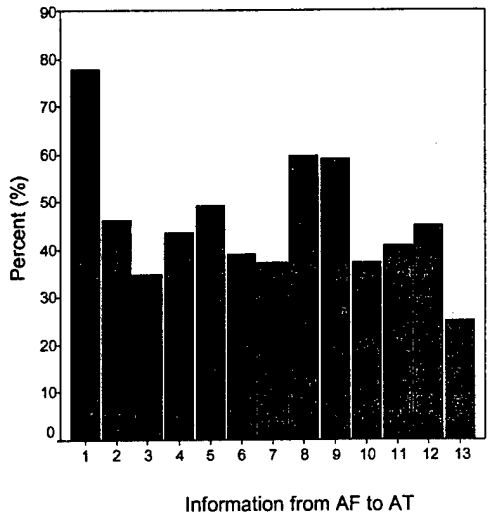
5. How soon do you usually give either approval or disapproval responses back to AF for a short-term (less than 5 hours to complete) Scheduled Event? : 5 hours 22 minutes

6. How soon do you usually give either approval or disapproval responses back to AF for a long-term (5 or more hours to complete) Scheduled Event? : 1 day 12 hours 30 minutes

C. Outage (equipment failure or improper operation) coordination

1. What percentage of time does AF provide the following information to you when they are coordinating restoration of an outage?

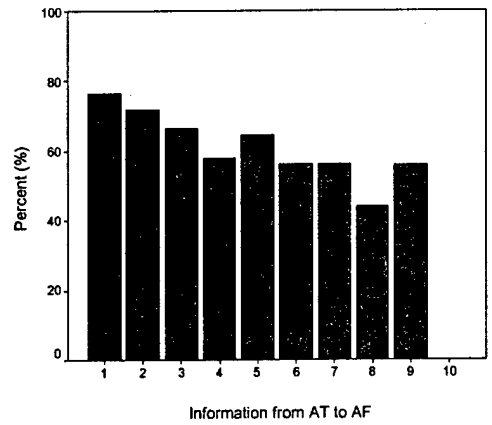
AF provided the information about expected restoration time (Item 1), equipment and services affected (Item 8), and cause of event (Item 9) to the AT most frequently.



1. Expected restoration time (95)
2. Are there other events scheduled that this event would impact? (e.g., Scheduled Events that may need to be cancelled) (94)
3. Status of adjacent facilities (95)
4. When are the other facilities expected to be returned to service (RTS) (95)
5. Activities needed to restore (94)
6. Availability of staff if an alternate time is needed (93)
7. Frequency of status updates (92)
8. Equipment and services affected (92)
9. Cause of event (95)
10. Availability of technicians with necessary skills (95)
11. Status of technicians (e.g., on site, en route, expected arrival time) (94)
12. Status of needed parts (e.g., availability) (96)
13. Other (9)

2. What percentage of time do you provide the following information to AF when they are coordinating restoration of an outage?

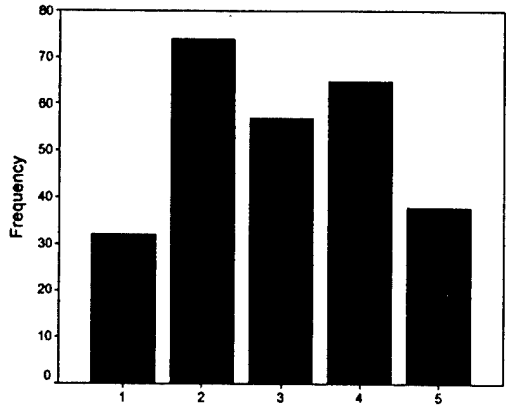
AT provided AF with the information of the potential factors that could influence the maintenance schedule (Items 1, 2, and 5) most often. "Restoration time requirements" (Item 3) was another information AT provided to AF frequently.



1. Potential impact on NAS operations (95)
2. Potential traffic delays (95)
3. Restoration time requirements (94)
4. Relative importance to the flow of traffic at other facilities (94)
5. Current and expected weather conditions (95)
6. Backup systems or procedures in use during the time of the event (94)
7. Special conditions that may be impacted (e.g., VIP flight) (94)
8. How well the transition to backup proceeded (94)
9. Air traffic restrictions implemented (94)
10. Other (Please specify.) (12)

3. What parts of outage coordination with AF are currently recorded?

The coordination interactions with AF (Items 2, 3, and 4) are recorded most often. Not all exchanges between the AF and AT are recorded by AT respondents.

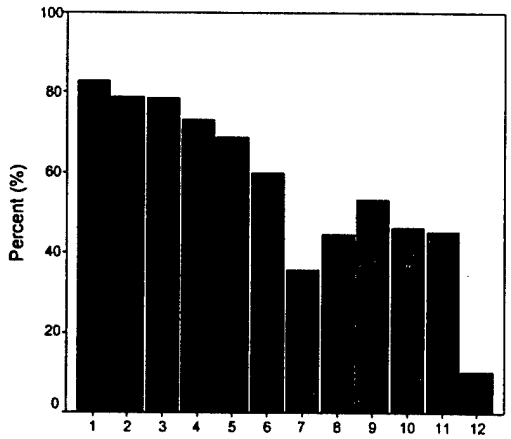


1. All exchanges between the organizations (57)
2. Initial contact between AT and AF (62)
3. Contact with AF resulting in new information (58)
4. Updates to AT by AF (55)
5. Other (Please specify.) (8)

D. Flight Inspection (FI) coordination

1. What percentage of time does AF provide the following information to you as they coordinate Flight Inspections?

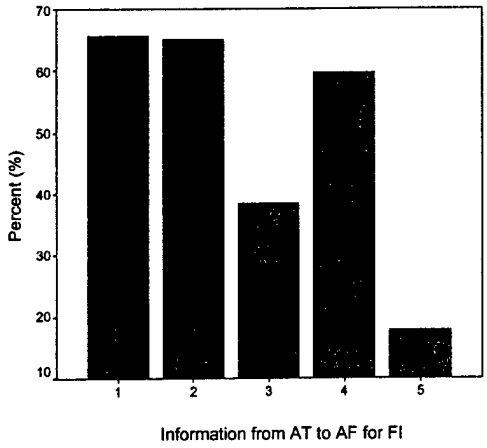
AF provided the information of facility (Item 1), time (Item 2), and specific place to inspect (Item 3: "Identifier" and Item 4: "Runway number") more than 70% of the time. AF also provided the information about the estimated length of inspection time (Item 5) and types of inspection (Item 6) about 70% and 60% of the time, respectively. AF also informed AT of the consequences of not being able to complete the FI (Item 9) more than half of the time.



1. The facility being inspected (154)
2. The time requested by AF and FI personnel (156)
3. The identifier (153)
4. Runway number (if ILS system) (146)
5. Estimated length of the inspection (154)
6. The type of inspection (153)
(e.g., routine, post accident, or a commissioning FI)
7. Whether AT person needs to be designated for entire FI (146)
8. Preferred alternative schedule if required (151)
9. Consequences of not being able to complete the FI (154)
10. FI aircraft tail number (151)
11. Pattern of flight in airspace (151).
(e.g. circling in a particular area, landing, etc.)
12. Other (Please specify.) (15)

2. What percentage of time do you provide the following information to AF as they coordinate Flight Inspections?

AT provides AF with information on future traffic conditions at the time of FI (Item 1), effect on traffic flow (Item 2), and the possibility of interruptions of FI (Item 4) more than half of the time.



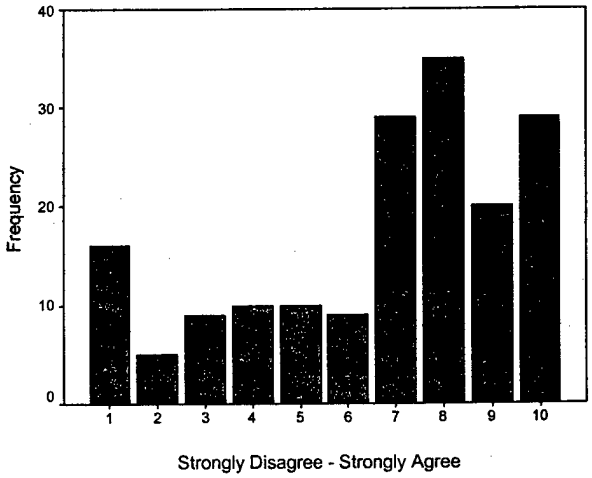
1. Expected traffic conditions at time of scheduled FI (153)
2. Effect on traffic flow (153)
3. Availability of AT personnel to help FI if needed (147)
4. Are interruptions to the FI possible (e.g. due to traffic) (150)
5. Other (Please specify.) (17)

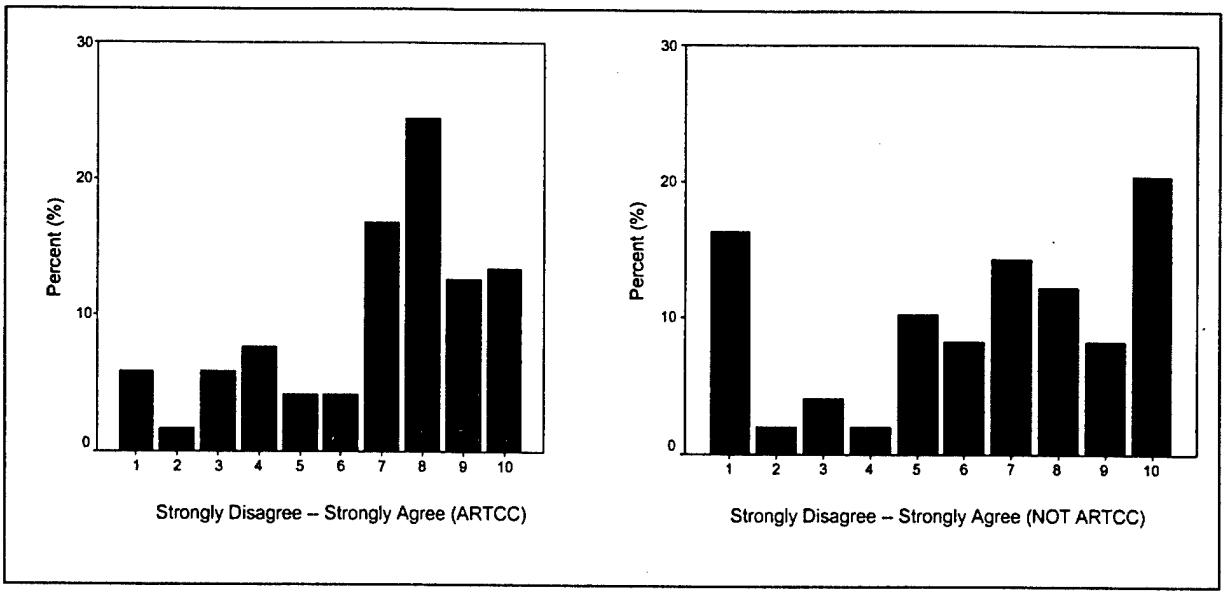
E. Your opinion

1. There are clearly defined roles for coordinating with AF.

The mean score was 6.7. This means that overall, AT respondents agreed that there were clearly defined roles for coordinating with AF, but they did not agree with it strongly. Sixteen participants (9%) out of 172 respondents strongly disagreed (rating 1). This contrasts with the fact that 29 of them (17%) thought strongly there were clearly defined roles for coordinating with AF.

The mean ratings of ARTCC respondents and non-ARTCC respondents were 6.87 and 6.29, respectively. The *t* test showed that the responses of the two groups were not significantly different, $t\,(74) = 1.12, p > .05$. The degrees of freedom was adjusted because the assumption of equal variances was rejected. Without the adjustment, it should have been 161.





2. What are the most successful aspects of current AF/AT coordination? (The results of this question are summarized in Appendix E.)

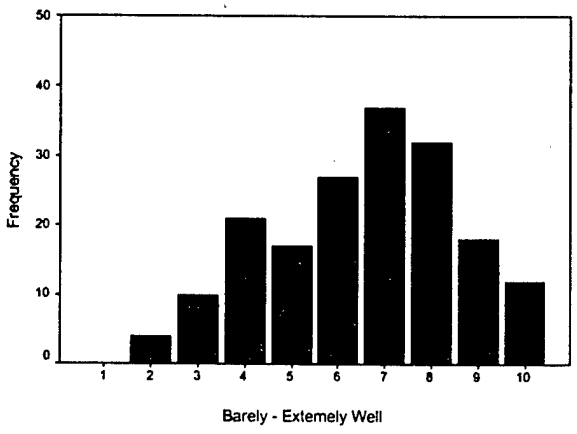
3. Please describe any obstacles you currently face with coordination. (The results of this question are summarized in Appendix E.)

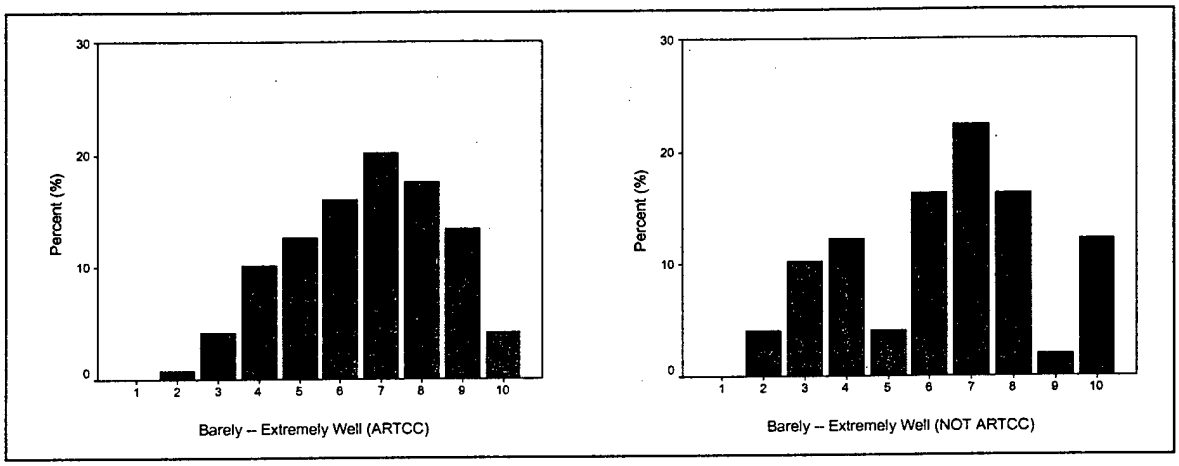
4. Please describe any suggestions you have for improving the current coordination process with AF. (The results of this question are summarized in Appendix E.)

5. How thoroughly do you understand AF tasks and responsibilities?

The mean rating was 6.6, which was close to be neutral (rating 5.5). This means that overall AT personnel thought that they understood AF tasks and responsibilities. But they did not think in a convincing way.

The mean ratings for ARTCC respondents and non-ARTCC respondents were 6.64 and 6.35, respectively. The two groups' ratings were not significantly different (t (165) = .380, $p > .05$).

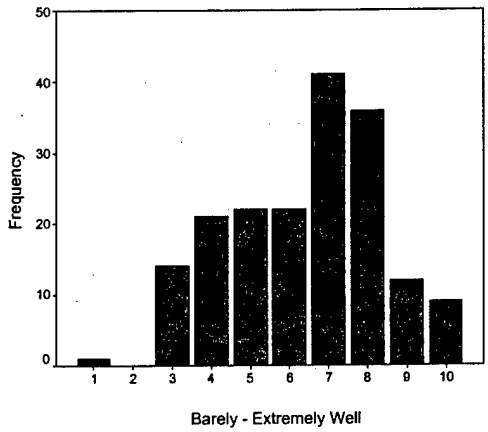


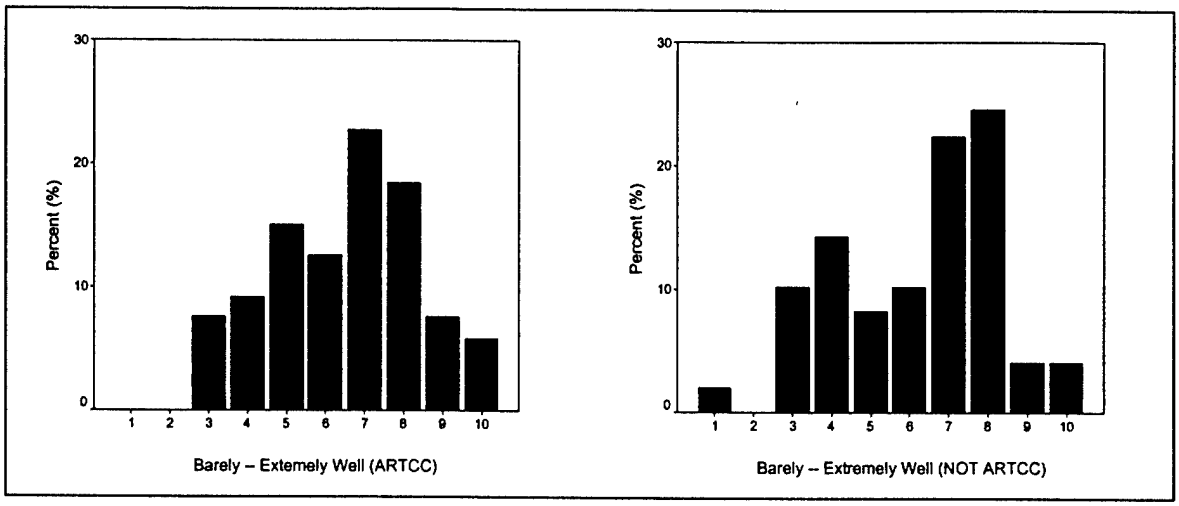


6. How thoroughly do you think AF specialists understand your roles and responsibilities?

The mean rating score is 6.4. This is close to neutral (rating 5.5). The number of participants who gave ratings of 7 and 8 were 69 (39%).

The mean ratings of ARTCC and non-ARTCC respondents were 6.5 and 6.2, respectively. The ratings of the two groups were not significantly different (t (165) = .830, p > .05).

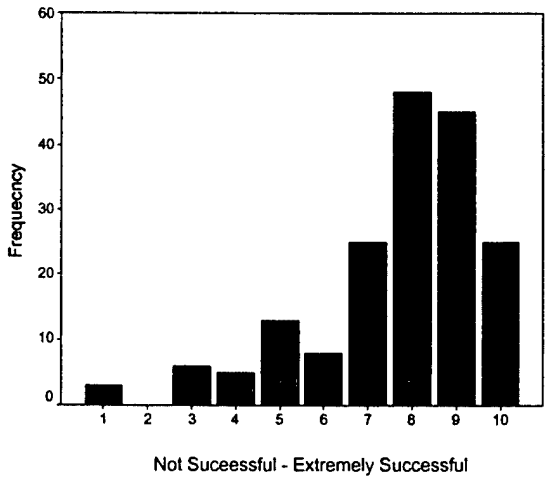


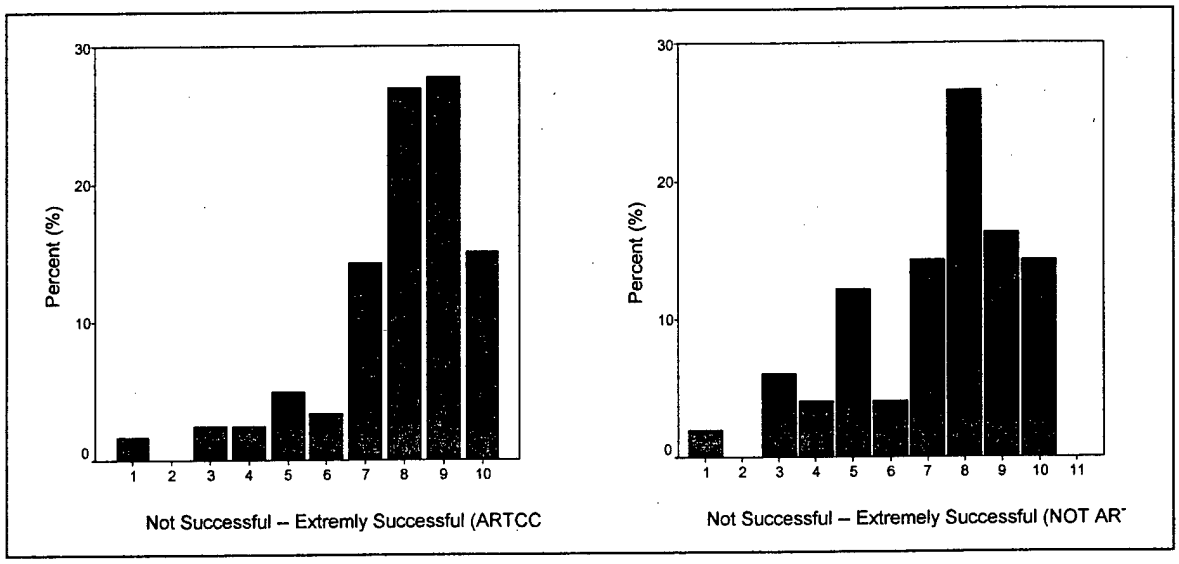


7. How successful is current AT/AF coordination?

The mean rating is 7.7. This means that they think the current coordination is successful to some degree but needs improvement.

The mean ratings of ARTCC and non-ARTCC respondents were 7.9 and 7.2, respectively. The two groups' ratings were not significantly different (t (165) = 1.870, $p > .05$).




Percent (%)
30
20
10
0
1 2 3 4 5 6 7 8 9 10
Not Successful -- Extremly Successful (ARTCC
Percent (%)
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11
Not Successful -- Extremely Successful (NOT AR

APPENDIX E

Summary of Open-Ended Questions

(Note: MOST OF THE RESPONDENTS GAVE ONE OPINION TO EACH QUESTION, BUT SOME GAVE MORE THAN ONE RESPONSE.)

			AF	AT
MOST SUCCESSFUL ASPECTS	Working relationship		31 (trust, good working relationship, mutual respect, trust, good cooperation, team work, credibility, confidence, personal relationship, rapport, understanding)	40 (good working relationship, compromise, mutual respect, helpful, trust, good cooperation, team effort (spirit), knowing the people involved, rapport, long standing personal relationship)
	Face-to-face coordination		18 (face-to-face contact, face-to-face coordination)	24 (close physical location, face-to-face communication)
	Information	Source (other than staffing)	3 (to know the person on duty in AT, one on one coordination, facilities with a single AT coordination point)	17 (paging system, accessibility of AF, one call, one point of contact, one person contact, one central POC, NOM coordination, up-to-dated check lists, whom to call, one-on-one coordination)
		Sharing, Exchanging	1 (smooth transition of information)	3 (constant information exchange on equipment)
		Quality		1 (accurate information)
	Knowing the other's needs and responsibilities		11 (know the impact to air traffic, reduced impact to overall NAS, a mutual understanding of both AF and AT requirements, knowledge of AT operation, MCC has a clear picture of what facilities are out of service and what the impact is)	6 (understanding each other's need, requirements, and responsibility, knowledge of the other's operations, knowing the other's strength and skills)
	Local control		3 (close proximity, same floor with AT)	15 (close proximity, onsite AF personnel, the use of MCC as local)
	Attitude, Personality		2 (attitude, personalities)	4 (willingness to assist and listen to concerns, attitude of being on the same team)
	Meetings and plans		2 (weekly meetings with major players, AF going to AT briefings twice a day,)	3 (weekly meetings, twice a day meetings, plans, regular meetings, good schedules)
	Competence		2 (knowledge of the NAS)	1 (know what to do)
	Communication		1 (communication)	11 (MCC as focal for notification, NOM is helpful and customer service, facility paging system, clear communication)
	Responsiveness		1 (timely release)	7 (response and professionalism, quick response, timeliness, They answer the phones quickly.)
	Procedure			11 (easy and timely communication procedure, advanced communication, clear and accurate communication, good communication [empathy])
	Other		9 (good risk management, event manager)	7 (MCC, interaction with AF techs)
	None		0	8
	Missing		21	30

			AF	AT
Obstacles	Information	Source (other than staffing)	12 (too many layers to go through, too many coordination points, finding technicians after hours and off-peak hours, unnecessary layers, coordinating with contractors)	18 (too many units to coordinate, too many layers, hard to find someone on weekends, who is POC, uncertain of whom to coordinate with, no one answers phone or radio, always being sent to someone else)
		Source (staffing)	5 (AF staffing reduction, both AF & AT staffing, lack of maintenance personnel)	21 (low AF staffing, sometimes coordination process and work efforts impaired by AF's short staffing, shortage of personnel on both sides)
		Quality	2 (inadequate information)	4 (duplicate, poor information, availability of information)
		Sharing, Exchanging		1 (information not handed down)
		Terminology	1 (communication problems because of different terms)	7 (no common language to describe components)
	Responsiveness		12 (AT's reluctance of releasing, timely approval, AT's stalling approvals, AT being in a big hurry and forget to give information, AT managers too busy to give all the confirmation needed)	3 (short notice, timely explanation of how long the outage would last and how soon it would be fixed, trying to have an individual acknowledge that info is being passed)
	Competence		8 (limited knowledge of some systems, incompetence of co-workers, AT personnel not familiar with the entire system, lack of seeing the effects of maintenance on the big picture)	16 (A couple of people are lazy and unskilled, reaching someone who knows how to fix, The MCC personnel do not have any clue as to what equipment is critical or not.)
	Procedure		4 (no set procedures for dealing with the military, too many boxes to check	6 (incomplete coordination, not following the procedure by AF and AT, lack of action to follow up on long-term events by AF)
	Time		4 (time restraints, AT gets too busy, short time request from field)	5 (time, controllers' having time to go through checking systems)
	Local control		3 (OCC concept)	1 (physical distance, side by side)
	Communication		3 (interfacility communication with AT, telephone communication)	
	Management		3 (controller union, micromanagement by AF, too much management)	
	Knowing each other		2 (not knowing enough about AT operation, keeping AT counterparts abreast of new systems)	13 (AF's lack of AT's needs and operations, do not understand the significance of intermittent equipment problems, AT's lack of knowledge of equipment, AT's lack of knowledge about AF's job)
	Attitude, Personality			2 (bad attitude and personality)
	Working relationship			1 (AF's continuous comparing their roles with AT's)
	Other		5 (weather, ATC workload, pay difference, frequent Event Manager updates)	7 (weather, low morale in AF, funding to replace equipment, NATCA)
	None		9	40
	Missing		28	38

			AF	AT
Suggestions	Information	Source (other than staffing)	5 (availability of technicians, try to integrate information systems between AF and AT, single point of contact for large ATCTs)	13 (remove coordinator position, remove SMO, have one point of contact, too many things are given to MCC to coordinate,, someone should be in charge at the AF, AF and AT should have an easily updated single source of information.)
		Source (staffing)		15 (hire more AF staff)
		Sharing, Exchanging		4 (keep lines of communication open, information sharing instead of waiting to be requested)
		Terminology		2 (standardized nomenclature)
	Local control		9 (keep local control, keep MCCs at large airports, rethink the OCC)	6 (keep MCC here, don't centralize)
	Knowing each other		8 (understand the other's roles, job, and responsibilities, better understanding of the other's operation, AT needs to understand what AF does, have ATC supervisors sit with AMCC personnel for a few shifts)	10 (familiarization for all from both AT and AF, I would like to know more about AF obstacles, AF and AT need to spend more time in the other's work area, shadow once a month, joint meeting/training, greater knowledge of equipment by AT)
	Communication		6 (keep communication s open, utilize web sites, better communication, develop common local network)	1 (better communication, including follow-up and updates on equipment status)
	Working relationship		5 (AF is not a janitor, good working relationship)	2 (personal relationship, better AF management and labor relationship)
	Responsiveness		2 (ATC should provide a reply within half an hour of receiving request, AT needs to advise AF whenever delays have started. Presently we hear about them after the fact.)	3 (timely updates on status of problems, keep air traffic informed of current status of outages-periodic updates, timely updates as to the status of the situation)
	Procedure		1 (streamline coordination between AF facilities in AF)	10 (establish comprehensive schedules, come up with a printed schedule of all necessary maintenance, a written procedure, better coordination of flight inspection)
	Pay		2 (equal pay)	1 (increase their pay to match AT's)
	Time		2 (more time to schedule the Scheduled Events, real-time talk among pilots, Aviation Systems Standard, and MCC)	
	Competence		1 (select only persons with background to be able to do the jobs at MCC/OCC)	1 (better competent field technicians)
	Meetings and plans		1 (more joint AF/ATC/MCC information-exchange meetings)	
	Other		2 (stay with something that works and do not change it all the time)	4 (better documentation/computer log entries for both parties, remove NATCA involvement, better contractors' response time)
	None		9	26
	Missing		43	81